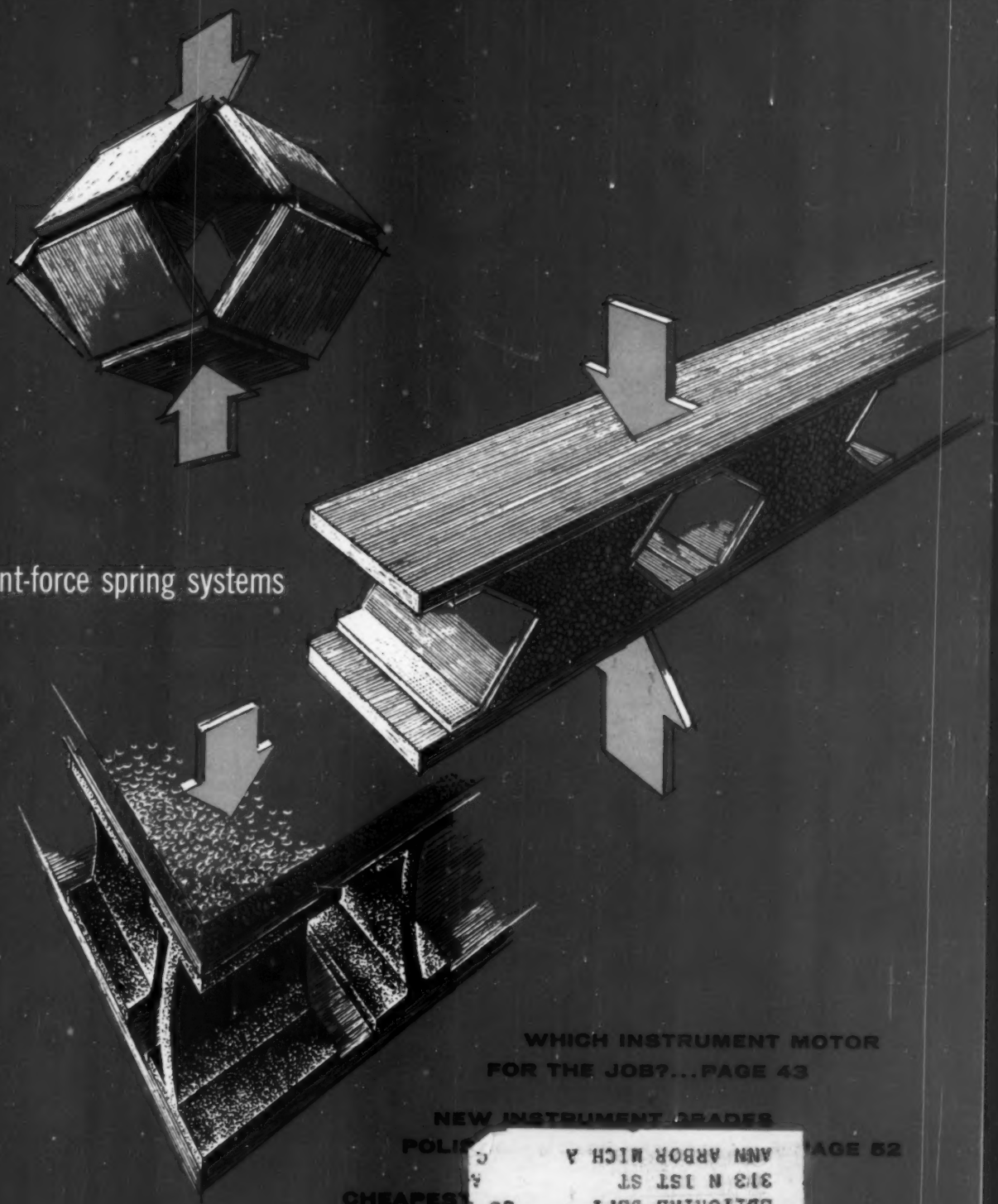
# PRODUCT ENGINEERING

cGRAW-HILL WEEKLY FOR DESIGN ENGINEERS · MARCH 27, 1961



new constant-force spring systems

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NEW INSTRUMENT GRADES POLI... ...AGE 52

CHEAPEST ... GS TO PRODUCE...

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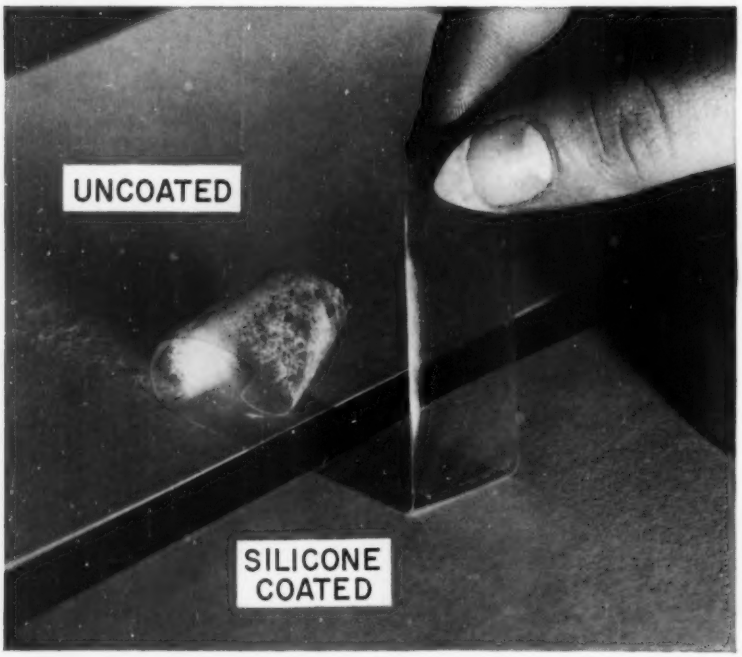
**SILICONE NEWS from Dow Corning**

# No Sticking Here!



## New Silicone Coatings for Paper End Sticking; Save Time, Money

Sticky products like asphalt, dates, and uncured rubber have always been troublesome to pack, unpack or process. But that's all in the past for people who specify new Syl-off® silicone coatings for paper.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY FOR DESIGN ENGINEERS

March 27, 1961 Vol. 32, No. 13

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# How to choose a metal for high-temperature service

In every sense, "the heat's on" and "the pressure's on" when metals go to work at high temperatures. The basic trend in processing equipment has been toward higher pressures, higher temperatures, and more corrosive conditions.

**That's why questions like these are being asked today:** What metal is used within the core of a gas-cooled reactor where operating temperatures go up to 1700°F? What metal is used for the "skin" of a missile that must take supersonic heats from 400° to 600°F . . . and be the structural framework for 130 tons of dead weight? What metal is used to withstand the corrosion of hot ammonia gas at 900°F? What metal is used for strength and corrosion resistance above 1000°F?

**The answer, in each case:** Nickel Stainless Steel.

Nickel works as a strengthening and toughening agent. In steel it promotes the formation of austenite, which is stronger and more stable at high temperatures than ferrite. Nickel steps up steel's resistance to oxidation, carburizing, nitriding and thermal fatigue.

**The war against corrosion.** High-temperature equipment is exposed to a great many different atmospheres and corrosive conditions. Many materials coming from high-temperature processing and handling must be delivered uncontaminated by the products of corrosion. Nickel stainless steels are especially good for fighting corrosion . . . perform well under those oxidizing conditions harmful to unalloyed steel. The stainless steels possess the ability to protect themselves with oxide films that form a shield against corrosion. And *stainless* steel, as the name implies, stays brighter, cleaner . . . and the protective "oxide layer" is less likely to be broken or reduced by pitting or scaling.

**What strength means at high temperature.** By a mechanism known as "creep" metals at elevated temperatures flow plastically though subjected to stresses below their yield strength, as determined by short-time tensile tests. The creep strength of nickel stainless steels is an important reason for their increasing use in a variety of high-temperature operations. Both *time* and *stress* are design factors at high temperatures. The most generally useful data are those for creep and rupture—one or the other is the basis for most allowable stress values in design work.

The chart below gives the creep and rupture strength data of two nickel stainless steels that have found wide acceptance in high-temperature service:

| | CREEP STRENGTH | | | |
|---|---|---|---|---|
| | 1000°F | | 1500°F | |
| AISI TYPE | 1% 100,000 hrs, psi | 1% 10,000 hrs, psi | 1% 100,000 hrs, psi | 1% 10,000 hrs, psi |
| 310 | 17,500 | 32,500 | 1,250 | 3,500 |
| 316 | 14,750 | 24,500 | 1,800 | 4,200 |
| | **RUPTURE STRENGTH** | | | |
| | 1000°F | | 1500°F | |
| AISI TYPE | 100,000 hrs, psi | 10,000 hrs, psi | 100,000 hrs, psi | 10,000 hrs, psi |
| 310 | 21,000 | 25,000 | 1,600 | 2,800 |
| 316 | — | — | 1,600 | 3,400 |

**Don't stop at creep and rupture strength** . . . other critical questions must be considered in the selection of metals for high-temperature service. They include:

- high temperature ductility
- short-time tensile properties to help evaluate resistance to momentary overloads
- thermal shock resistance

**Before selecting a metal for a specific service ask yourself these questions:**

- ☐ What is the maximum temperature of operation?
- ☐ What kind of temperature cycling will occur?
- ☐ What maximum load will be encountered? Will it be constant or cyclic?
- ☐ What types of atmosphere or other corrosive conditions?
- ☐ What size or shape of the parts or sections?
- ☐ What further processing will be done, such as welding or machining?
- ☐ What abrasive or wear conditions will be encountered?

The nickel stainless steel family can serve you in a wide range of high-temperature operations. That's why it's best to bring your metal problem to Inco's High Temperature Engineering Section. They are fully prepared to give you practical answers on the metal that will work best in your application. A note to Inco will bring you the "High Temperature Worksheet" to guide you in describing your metal problem.

## LITERATURE

The publications listed below will provide more detailed information on choosing metals for high-temperature service.

| PUBLICATION NUMBER | NAME |
|---|---|
| A266 | Heat Resistant Castings, Corrosion Resistant Castings . . . Their Engineering Properties and Applications |
| A227 | Stainless Steel for Pressure Vessels |
| | High Temperature Corrosion in Refinery and Petrochemical Service |
| A164 | Thermal Expansion Characteristics of Stainless Steels Between −300°F and 1000°F |
| A248 | Compilations of Chemical Compositions and Rupture Strengths of Super-Strength Alloys |

A complete listing of Inco publications and technical bulletins can be obtained by writing for "List A" to:

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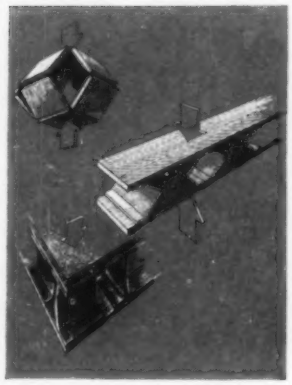
# INTERESTING TO NOTE



**On our cover**—examples of several constant-force springs for better isolation of shock and vibration. Springs like these have already improved the packaging of delicate instruments. Some are simply levers and springs, others are buckled-column combinations. For details, see article on page 54.

Packaging delicate instruments or complex components has often given the package designer more headaches than the engineer. In some cases the package itself has been put to use in applications never conceived by the designer. After World War II, for example, a group of farmers in upstate New York found that they could buy surplus military gliders for under $100. They had no use for the precision-made aircraft, but the large pine shipping crate, lined with tar paper and reinforced with 4 x 4's made excellent prefabricated hen houses. Many of these glider boxes are still standing near Elmira, NY.

Petroleum companies have found that the Chinese have more use for the five-gallon containers used to ship kerosene than they have for the fuel itself. Peasants collect the empty drums and use them for carrying water, cooking food and other domestic purposes. And tourists in the Caribbean can't help but hear the music from native steel bands—rhythms pounded out on old empty oil drums.

## Price Control Through the Ages

Economics, a relatively new name for an old science, plays a part in whatever engineers do—they must constantly keep an eye on costs. As the article on page 60 points out, the way to save money when producing metal parts depends on such factors as complexity of the part, quantity produced, and cost of material.

Throughout history, every society has been concerned with the price structure, and has sought to maintain some controls over it. In ancient societies, price controls were common. Egyptian Pharaohs set up a predecessor of the OPA by fixing the exchange value of goods being traded in the market place. But in spite of the law, the black market was common. In 301 AD, the Roman Diocletian fixed prices of food, raw materials and manufactured goods. However, even the threat of death did not make his edict enforceable. Centuries later, merchants in Northern Europe formed guilds to hold a tight control over the price and quality of all goods sold. They were a stabilizing force, but abuses of power eventually toppled the guild system.

In early America, prices were usually determined by trial and error—nomadic peddlers would set prices according to a personal estimate of what the market would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bear. There was no such thing as a firm price on any commodity—the market was flexible with a final price reached by haggling. For most products, there was no clear concept of production cost. The town market was more than a place to buy and sell goods. It served as a gathering place for the local gentry, the distribution point for news, and usually the town's postoffice as well.

### End of the Iceberg?

Several years ago, a sporting-goods dealer in New York City was arrested for selling air guns without a license. The proprietor protested and during his trial tried to convince the judge that his "air gun" was actually powered by carbon dioxide, not "air." The judge realized that the defendant was quibbling over a technicality, but decided in his favor anyway. The "air gun" was actually a spear gun for underwater fishing and the judge ruled the law was intended for surface rifles. Small carbon dioxide cylinders are being applied to many products formerly powered by a simple spring or windup mechanism. On page 50 are details on a camera that is self-winding—thanks to a $CO_2$ cartridge.

Although carbon dioxide constitutes only 0.03% of the gases in the atmosphere, it is vital to the safety and well-being of planetary life. Carbon dioxide acts like a blanket around the earth allowing the sun's visible rays to enter, but at the same time holding back heat radiated by the earth. According to Dr Gilbert Plass, an American atmosphere physicist, factories, autos and airplanes are putting more carbon dioxide into the atmosphere than nature can absorb by photosynthesis. Dr Plass claims this surplus of $CO_2$ will "have a profound effect on our climate." He calculated that we are increasing the carbon dioxide concentration in the atmosphere at the rate of 30% each century. This would produce an average rise in temperature of 2 degrees F per 100 years, which corresponds almost exactly to the rate at which the earth's temperature actually has risen since 1900.

This shouldn't cause a great deal of immediate alarm, but when we realize that an increase of only 7 deg would melt the polar ice caps, our children around 2300 A.D. may have some fun boating down the main streets of New York.

—Benedict A Leerburger Jr

## SIDELIGHTS

The language of science is not confusing enough, space scientists are now dreaming up new words for an already overburdened vocabulary. "Kluge" is an example. It means a temporary device to save time. Any small igniter is a "squib." The 16 tubes into which the Polaris missiles fit are known to technicians and crew as "Sherwood Forest." That dark and gloomy submarine bilge is now the "mushroom factory." Our favorite is "yozzle." You yozzle (turn) a gyro system to find out where it binds.

For those worried about buying a radioisotope with a short half-life and having half the half-life spent in transit, the AEC has changed its mailing policy to assure that almost all radioisotopes will be shipped "with radioactive content calculated to 8 AM of the day following shipment at no extra cost." Now only the postman has to worry.

## NEXT WEEK IN PRODUCT ENGINEERING

**. . . Universal Standard for Printed Wiring Boards**
These military standards are backed by lots of field experience. We can use them as a guide for minimum requirements.

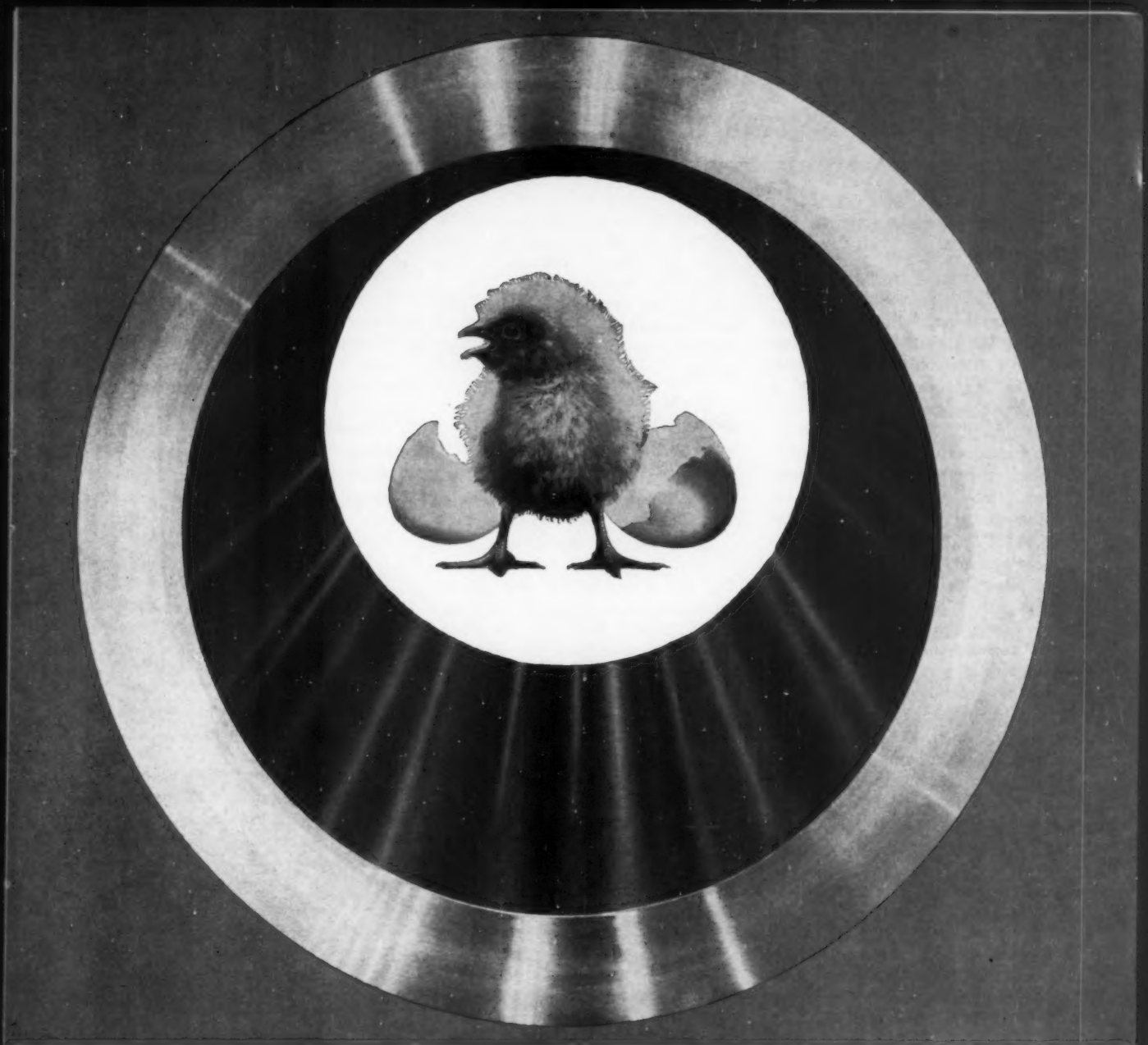
**. . . Plaster Die Gives Accurate Prototypes for Diecastings**
Make a wood pattern of the part to be produced, and from this a plaster mold. Then inject metal at low pressure and you have a reliable guide for pre-production tests.

**. . . New Mechanism Stops Spin of Rotating Masses**
"Yo-yo" despinner changes the geometric configuration of a spinning body by letting two small connected masses unwind from it.

**. . . Can Machines Really Learn?**
Simple learning machines are technologically possible, and experiments now in laboratories may pave the way toward more sophisticated devices.



CIRCLE 5 ON READER SERVICE CARD→



# WHAT'S NEW IN TUBING?

Here's another ACIPCO "first"... ACIPCO CERAM-SPUN®, the ceramic mold process* that offers greater versatility in design, new concepts in economy.

**WHAT THESE ADVANTAGES MEAN TO YOU!** ACIPCO is not limited by equipment sizes. Now, for the first time, you can order the exact tube O.D. you need... from 2.25" to 50". As-cast lengths can vary from 4 feet to 20 feet, longer lengths are made by welding; and wall thicknesses range from .25" to 8". Furthermore, these tubes can be furnished with the exact combination of physical, chemical, and metallurgical properties required by your specifications.

**THE RESULT: YOU SAVE MORE!** No more unnecessary metal waste or excessive machine charges.

Too, ACIPCO's complete "under one roof" operations — including heat treating, machining and welding — eliminate the delays and additional high costs often involved in buying from multiple sources. Before you order another steel tube . . . first investigate the many advantages ACIPCO offers. Contact ACIPCO STEEL PRODUCTS, Division of American Cast Iron Pipe Company, Birmingham 2, Alabama.

*Patent applied for

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STEEL TUBING

# WHAT'S HAPPENING IN RESEARCH . . .

## Structural materials rated for erosion resistance

The resistance of several structural and hard-facing materials to particulate erosion is detailed in a report prepared by W. L. Bulkley of American Oil Co's Research & Development Dept for the American Institute of Chemical Engineers.

Pointing out that erosive wear resulting from the action of highly mobile solid particles in a fluid stream is influenced by both the nature of the solids and the fluid mechanics of the system, Bulkley notes that rate of wear is proportional to a large power of the fluid velocity and is also related to the first power of solids concentration.

At American Oil, a series of tests and measurements have been made, including a simulated erosion test at several impingement angles. Of all the systems tried, a 30° angle seems to give the best results and correlate best with experience in service. Using the erosion rate of carbon steel at 30° impingement as the index, and making it equal to 1, wrought low alloy steel shows an index of 0.78; cobalt-base hard facing alloys, 0.26; high-chrome hard facing, 0.16; tungsten carbide, 0.005. · Aluminum, on the other hand, has an index of 6.0; 304 stainless, 1.1; and cast cobalt-base alloys show indices of 0.07 and 0.10.

## Elastic properties calculated for laminates

Filament shape as well as spacing and matrix material influences the elastic properties of orthotropic monofilament (wire-reinforced) laminates, J. C. Ekvall of Lockheed reports. He's developed equations for determining axial and shear stiffness and Poisson's ratio of such laminates—equations that can serve as a basis for structural design and are also expected to help design monofilament laminates to meet specified requirements for elastic properties.

Shear stiffness is also quite sensitive to laminate thickness and, Ekvall says, shear-deformation data should be included in calculations of bending stiffness if there is an appreciable amount of low-modulus material between layers, or if the majority of the layers are aligned transverse to the direction of bending.

A report, detailing results of tests on music-wire–epoxy-resin laminates has been prepared for ASME presentation.

## Selecting materials for radiation environments

Even at 600 F, magnesium is a better choice than the far-more-refractory zirconium when a tensile strength is plotted against neutron absorption, Phillips Petroleum engineers report. But use of magnesium alloys in nuclear reactors is limited by their lack of resistance to hot water. Beryllium, which scores highest on a tensile strength/neutron absorption basis, lacks the desired ductility for structural use. Zirconium is rated third on this basis; but its relative ease of fabrication and its corrosion-resistance often make it the primary choice.

Neither aluminum nor stainless steel scores as high as these three; but both are widely used because of cost, availability, ease of fabrication. Below 400 F, aluminum is preferred; above that point, stainless is better.

Plots of creep stress against temperature give similar results. In a report prepared for an AIChE symposium, W. C. Francis and J. M. Beeston of Phillips Atomic Energy Div note that magnesium shows up well in the 400 to 800-F range. Stress to produce secondary creep rates of 0.001%/hr is on the order of $10^4$ psi.

The effects of radiation on these "nuclear metals" must also be counted in selecting structural materials for radiation environments. Here, there are serious problems of embrittlement but also are beneficial effects. As S. H. Bush of GE pointed out to the Los Alamos symposium on nuclear materials, irradiation frequently increases tensile and yield strength, sometimes as much as 400%. However, he warns, tensile elongation and reduction in area may be decreased; and, he says, "there is a definite decrease in the work-hardening of metals which might impose severe limitations in design."

## Contaminants are clue to polyethylene adhesion

Poor adhesion of polyethylene may be traced to contaminants exuded from the material itself, says J. J. Bikerman of MIT. This, rather than natural lack of adhesiveness or use of poor adhesives may be a major cause of peeling.

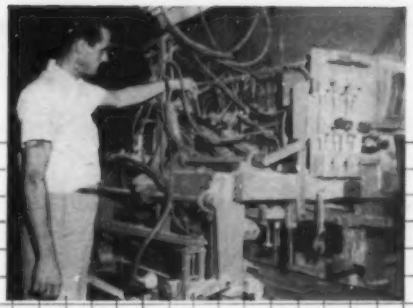
Tests at the MIT Dept of Sanitary and Civil Engineering indicate that polar additions like oleic acid, even in quantities of less than one percent, may reduce peel strength by a factor of 5 or more.

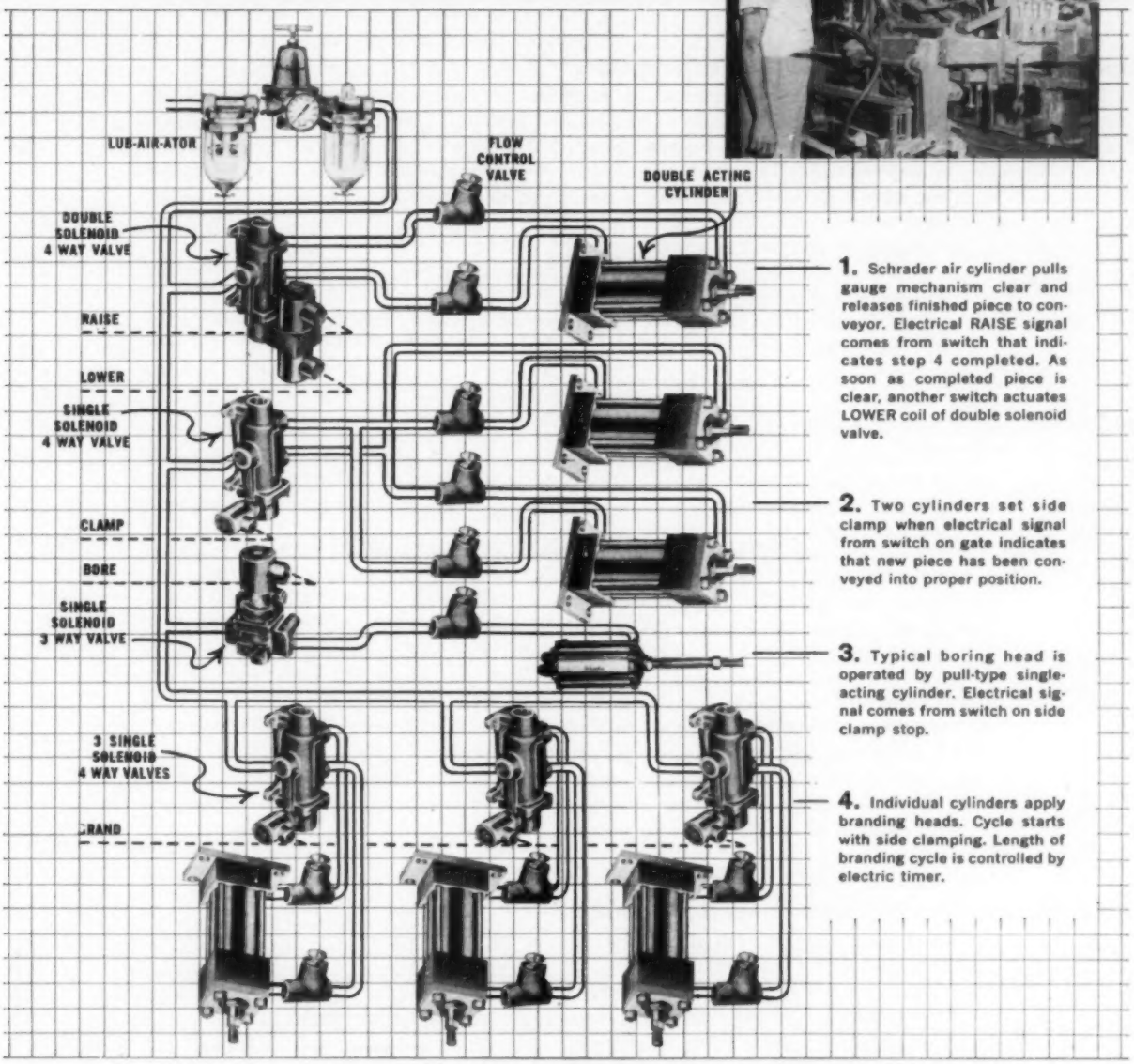
A report, detailing results of tests using polyethylene waxes to attach strips of aluminum to glass, has been prepared for this week's ACS meetings. **—ARG**

## Regulation-free atoms in new kit

Radioactive isotopes which may be purchased without an AEC license are offered by Nuclear-Chicago Corp in this lab kit priced at $59.50. The kit includes 5 vials, plus a syringe and instruction manual. The lead-bismuth and cobalt vials contain 10 ml; the other three, 5 ml. Half-lives range from 5 to 5600 years.

The Lane Furniture Company of Altavista, Virginia, broke its cedar chest production line into groups of operations for air-automation. One of the many circuits, shown here, was designed with quality Schrader components to brand the chest tops with a trademark, bore hinge recesses, and perform vertical and horizontal gang drilling operations. All three jobs are completed in less than 30 seconds!






**1.** Schrader air cylinder pulls gauge mechanism clear and releases finished piece to conveyor. Electrical RAISE signal comes from switch that indicates step 4 completed. As soon as completed piece is clear, another switch actuates LOWER coil of double solenoid valve.

**2.** Two cylinders set side clamp when electrical signal from switch on gate indicates that new piece has been conveyed into proper position.

**3.** Typical boring head is operated by pull-type single-acting cylinder. Electrical signal comes from switch on side clamp stop.

**4.** Individual cylinders apply branding heads. Cycle starts with side clamping. Length of branding cycle is controlled by electric timer.

# MANUFACTURER AUTOMATES PRODUCTION LINE WITH SCHRADER AIR CIRCUITRY... COMPLETES 3 JOBS IN 30 SECONDS

If your plant has production lines too long, unwieldy and costly to compete effectively, take a tip: Break your entire manufacturing sequence into logical *groups* of jobs. Then develop air-powered and air-controlled machines to perform each group in sequence. This company did, and now has versatile, fast, and economical production. *You already have air.* Expand its uses with versatile Schrader Air Products and discover true efficiency.

*There is a fully stocked Schrader Distributor nearby . . . staffed with experts to help you solve any air circuitry problem. Consult the Yellow Pages or write:*

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# DEVELOPMENTS TO WATCH...

## *British design new two-speed induction motors*

Ac induction motors with only a single set of 3-phase stator windings have been developed in Britain and are to be produced there by Associated Electrical Industries.

According to Britain's National Research Development Corp, which sponsored the original research, the motors use a system of pole-amplitude modulation, in which the flux of a multiple-pole winding is modulated in amplitude much as a radio carrier wave is modulated. The modulation is achieved by a reversal in circuit or bypassing of successive parts of the winding.

Although the theory is complex, NRDC says manufacture is simple and the motors can be built with any speed ratio up to 1.5:1.

Additional information on the design may be obtained from the US representative of NRDC, Suite 503, Mercury Bldg, Washington 6, DC.

## *Navy standardizing fuel-filtration tests*

To develop a test that will be a good indicator of fuel stability, Naval Research Lab is now evaluating several systems. The basis: a measurement of filterability and filter-plugging tendencies that will indicate tendency of the fuel components to separate out during storage.

One test system is a constant-flow, differential-pressure method; another a constant-head, gravity-flow system. Good correlation has been found between the two, but porosity of the filter itself has been found to have a major effect on reproducibility of the test, an effect comparable to that of temperature. It is, as a matter of fact, so important that it will probably be necessary to specify a standard filter porosity as well as a standard test method and temperature to obtain a broadly useful system.

A report on the first phase of the study (NRL Problem CO1-03) is now in preparation and will be available in a month or two from OTS, Dept of Commerce, as PB161966; and further reports are planned.

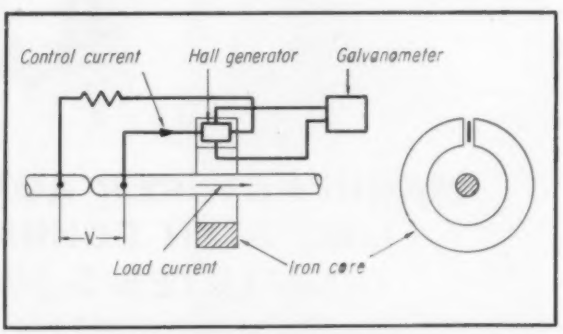
(Note: for a full-scale report on filter types and filtration systems see *PE—Nov 28 '60, p 29*; and for information on a major cause of fuel-fouling in storage—fungi—see *PE—Jan 18 '60, p 52.*)

## *Ac contact-resistance measurements simplified*

A simple and practical device for ac measurement of contact resistance, designed by ASEA of Vasteras, Sweden, takes advantage of the Hall effect (generation of a voltage across a semiconductor strip when it is placed in an alternating electrical field).

The semiconductor in this case is indium arsenide, and the setup (see diagram) is arranged for direct measurement of the active power.

When a Hall-effect generator is fed with an alternating current and an alternating voltage of a given phase displacement, the output voltage, ASEA says, will contain a dc component proportional to the active power. By measuring the output voltage with a galvanometer, it is then possible to determine directly the contact losses and thereby to obtain the contact resistance.




**TO MEASURE CONTACT RESISTANCE, semiconductor (Hall generator) is placed in the airgap of an iron core which surrounds the current-carrying conductor. Control circuit is connected to the two contact members between which the losses are to be measured.**

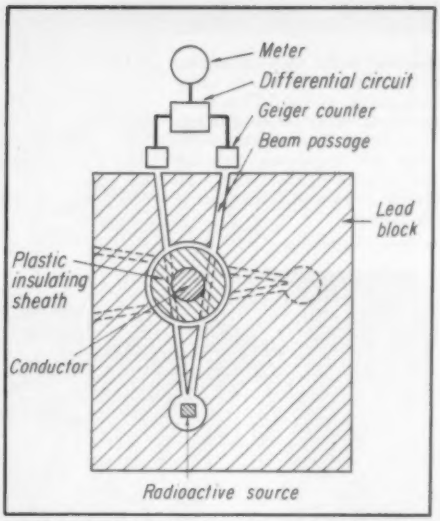
The prototype model has an accuracy of about 1.5% and a sensitivity of 0.1 mv/watt per turn on the core.

Note: ASEA's US office is at 500 Fifth Ave, New York 36.

## Isotopes measure cable concentricity

Intersecting beams of gamma radiation from radioactive-isotope sources form the heart of a new concentricity-measuring device developed by UKAEA engineers.

Designed to check cable-and-sheathing systems, the device consists of a lead block with a cavity for the radioactive source and the cable, and passages for the radiation beams. The passages carry the beams from the source, through the cable, to the surface where Geiger counter radiation detectors are mounted. The concentricity measurement is based on a comparison of the intensities of the transmitted beams after they have passed through the system. The angle of the beams is so adjusted that, if cable and sheath are concentric, the beams just intersect the edges of the conductor. Any variation from concentricity will then increase or decrease beam transmission. BP847,129 describes the system.




**CONCENTRICITY** of cable and sheathing can be measured with this isotope setup. Dotted lines show secondary system which may be provided to determine vertical displacement.

## Super-refractory fibers readied for laminates and molded parts

As reinforcement for plastic laminates and molded parts, single-crystal aluminum oxide "whiskers" and polycrystalline zirconium oxide fibers show considerable promise. Structural composites, thermal insulation, and ablation shields are among the possible applications. The zirconia fibers look especially interesting because they can now be made in both "wool" and filament form.

A report from H I Thompson Fiber Glass Co indicates that zirconia-phenolic laminates will have excellent short-term heat resistance, relatively low thermal conductivity, and good flexibility. They'll be relatively heavy though, since the density of zirconia itself is quite high.

## Titanium heads for 900 F

A new series of alpha titaniums, now in the pilot-plant stage, shows promise for use at temperatures from the cryogenic range all the way up to 900 F, Battelle Memorial Institute reports. These "super-alpha titaniums" offer considerably higher strength at elevated temperatures than do the present commercially pure alpha alloys, yet do not show the tendencies toward low-temperature embrittlement found in many beta and alpha-beta alloys.

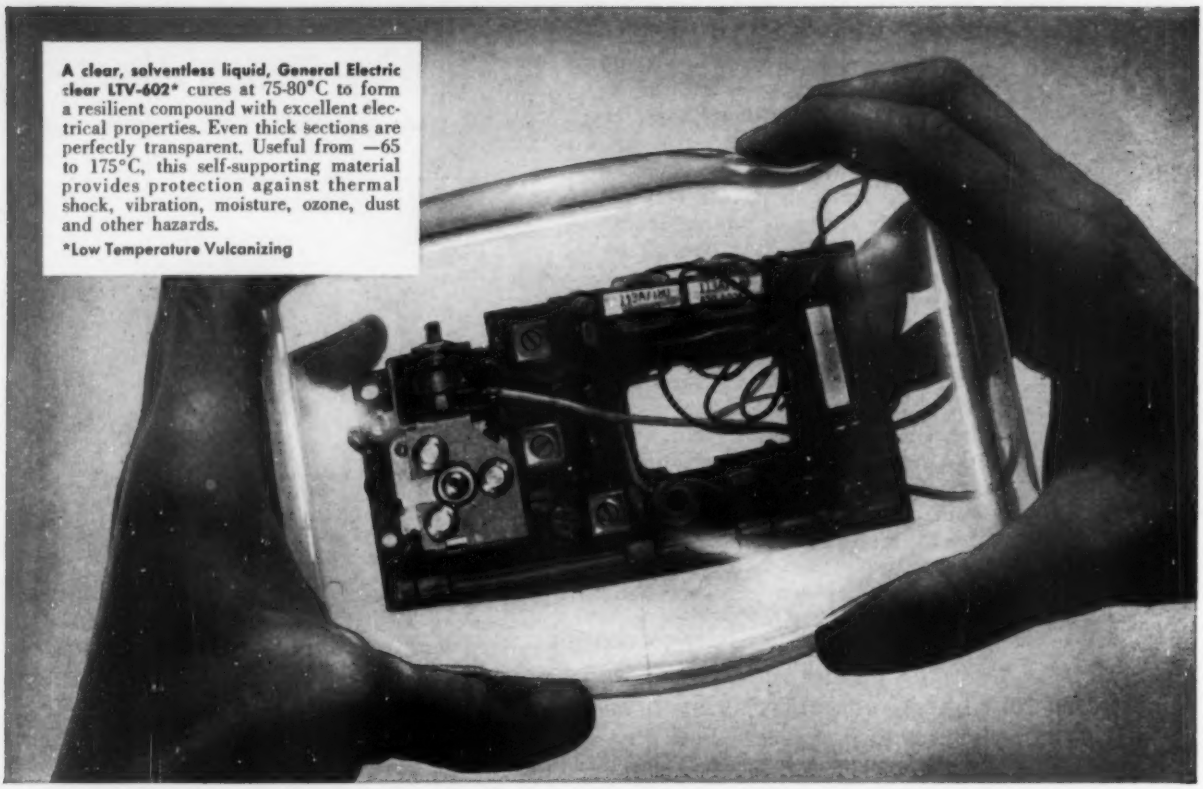
The new alpha titaniums are not ultrahigh-strength materials. But, Battelle says, they should meet the need for a non-heat-treatable, lightweight, moderate-strength material for long-term use at temperatures in the 900-F range.

Data on the new types is still fairly limited; but at least four companies are now headed toward commercial production.

## New coatings and adhesives from petroleum acids

Resins with unusual film-forming properties are reported by Pure Oil Co researchers. Made from a new type of dibasic acid derived from petroleum, they show promise for both coatings and adhesives. Alkyd-type baked films made with the new resins are said to have excellent adhesion, flexibility, impact resistance, and solvent and chemical resistance. Polyester-type resins can be prepared in which "any single desirable property can be emphasized by variation of the acid and glycol combinations used." Polyamides made with the new resins can be made into adhesives; and hard, shiny opaque epoxy-type materials can be produced.

A report on the investigations has been prepared by W. E. Kramer and Louis A. Joo of the Pure Oil Research Center for presentation to the ACS Division of Petroleum Chemistry; and further investigations are now under way. —ARG

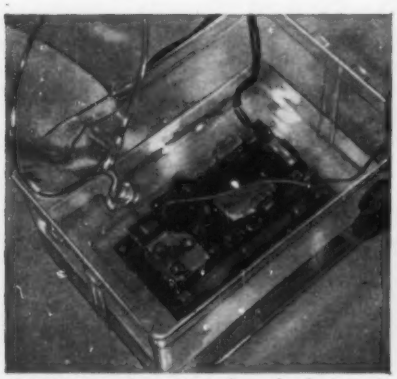


**A clear, solventless liquid, General Electric clear LTV-602*** cures at 75-80°C to form a resilient compound with excellent electrical properties. Even thick sections are perfectly transparent. Useful from —65 to 175°C, this self-supporting material provides protection against thermal shock, vibration, moisture, ozone, dust and other hazards.

*Low Temperature Vulcanizing

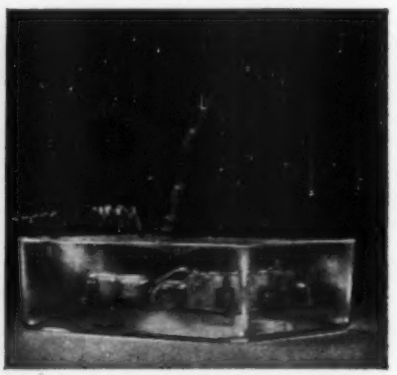
# General Electric clear LTV silicone compound for potting and embedding

*Transparent, resilient, self-supporting and easy to repair*



**LTV-602 is easily applied,** flows freely in-and-around complicated parts. Having a low viscosity in the uncured state, 800-1500 centipoise, LTV is ideal for potting and embedding of electronic assemblies. Unlike "gel-like" potting materials, LTV-602 cures to a flexible solid. Oven cure is overnight, or from 6 to 8 hours at 75 to 80°C.

**LTV-602 is easy to work with and easy to repair.** To repair parts embedded in LTV, merely cut out and remove section of material, repair or replace defective part, pour fresh LTV into opening and cure. Pot life, with catalyst added, is approximately 8 hours and may be extended with refrigeration. When desirable, LTV may also be cured at room temperature.



**Resiliency offers excellent shock resistance.** LTV-602 easily meets thermal shock tests described in MIL-STD-202A test condition B which specifies five temperature cycles from —65 to 125°C. Tests indicate that LTV retains protective properties even after 1800 hours aging at 175°C. Other tests confirm LTV's resistance to moisture and water immersion.

LTV-602 is the newest addition to the broad line of G-E silicone potting and encapsulating materials which also include the RTV silicone rubbers. For more information, write to General Electric Company, Silicone Products Department, Section A340, Waterford, New York.

GENERAL ELECTRIC

LINK-BELT Fan-cooled Worm Gear Speed Reducers

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These shock-absorbing reducers operate smoothly and quietly. Durable and compact, they are unsurpassed for adapting high motor speeds to modern production needs. Power is transmitted at either moderate or slow output speeds with ample capacity for heavy loads.

All types are fan-cooled. An aluminum radial fan directs a steady flow of air over the finned sides of the housing, resulting in cooler operation that pays off in increased hp for each center distance . . . lower initial cost.

Other design features include: automatic splash lubrication, durable centrifugally cast bronze-alloy gears, hardened, ground and polished nickel-steel worms and adequate roller bearings. Single and double lip oil seals ride on micro-finished shafts. High capacity involute helicoid worm threads assure accurate engagement.

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# FROM WASHINGTON . . .

## *Half of Lockheed's $1-billion government job to be subcontracted*

A $1-billion beefup of the nation's military troop and cargo-carrying capability has been started with the selection of Lockheed Aircraft Co as prime contractor for the building of a fleet of 100 or more such planes by 1965. The company was selected in competition over Boeing, Douglas and Convair. **However, fully 50% of work on the new plane—the SOR-182—must be subcontracted.**

Last Dec 30, the Air Force called for design proposals for the craft, stipulating that it must be capable of 440-500 knot speeds and carry 60,000-lb loads for 3000 mi or 20,000-lb loads for 5500 mi. It will be powered by four turbofan engines capable of operating from a 6000-ft runway. **As it is designed with a full-width, rear-loading ramp, the SOR-182 has commercial air cargo possibilities.**

## *City mail delivery to be more mobile*

The Post Office Dept has ordered 300 electric, 3-wheeled "mailsters" for use in city mail delivery. A $53,790 negotiated contract was placed recently with Highway Products Co of Kent, Ohio, with first deliveries due June 1.

**The new battery-powered vehicles will be built almost entirely from aluminum, and are expected to cut maintenance costs by about 50% as well as carry 60% more mail than conventional gasoline models now in service.**

Prototype vehicles have been tested in Miami and Houston by mail carriers. Some 90% of the men said they preferred the battery-powered vehicles to the conventional models. **Reasons: easier to handle (less fatigue for the carrier), quieter to operate, and faster acceleration between stops.**

The new mailsters (currently in use in Europe) are born of research conducted by the Post Office Dept and Highway Products. First use of the 300 vehicles will most likely be in southern states.

**Some other Post Office modernization programs started during the previous Administration are being dropped.** Postmaster J. Edward Daly has cancelled the department's program to develop a facsimile speed-mail system. This system was started several years ago with test transmissions made between Washington, DC, Los Angeles, Chicago, and Battle Creek, Mich.

**Reason for the shut-off: high cost of perfecting the system.** In addition, from its inception, the plan was strongly opposed by Western Union.

## *Navy's lighter-than-air program is abandoned*

The Navy will drop its lighter-than-air (LTA) program, giving as its reason, "The functions which airships perform cannot compete with the tactical importance of other naval programs for the defense dollar." **This will mean closing down the Navy's LTA department at Lakehurst, NJ.**

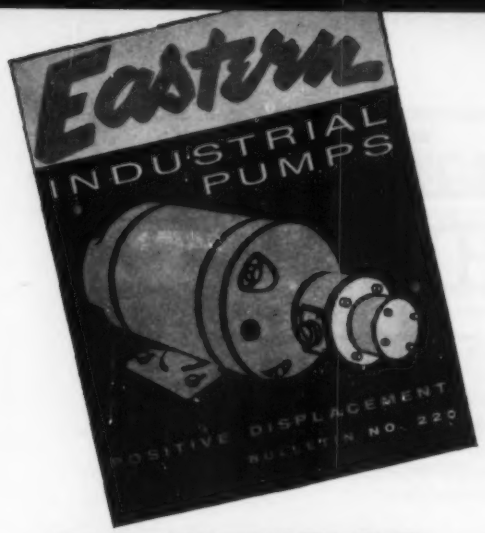
According to Sen Clifford P Case (D-NJ), the Sec of the Navy has said that no money is included in the fiscal 1962 Navy budget for the LTA program. **Sen Case may try to get the matter reconsidered, however, if only because the shutdown will mean dropping 489 civilian employes and the transfer of 625 military personnel.**

## *Maritime wants automated steam-turbine propulsion by '63*

The Maritime Administration has called for industry proposals to develop an automated steam-turbine propulsion system by 1963. To be handled in four phases, the program will start with a design study to be completed in 3 months. The next steps are contractor selection, prototype construction and installation of the powerplant in the ship. The rising cost of operating US merchant ships is sparking the new research program.



CIRCLE 13 ON READER SERVICE CARD →

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## POSITIVE DISPLACEMENT PUMPS

**If you have a performance requirement for pumps which can deliver a pulsation-free flow of non-lubricating liquids at pressures up to 200 psi on the gear type or rates up to 6 gallons per minute on the vane type, pick a winner from the big Eastern line.**

**For small volumes against relatively high pressures, the Eastern GW series gear pumps are a natural. In each pump, oversized bearings of impregnated graphite support a drive gear of stainless steel and an idler of special bronze material. These self-priming units require no lubrication and cannot contaminate the liquid being pumped.**

**For volumes from 1.5 to 6 gpm and pressures to 60 psi, you can't beat Eastern VW series vane pumps. These highly efficient units are designed around a cam-shaped pumping chamber assuring pulsation-free liquid flow. Vanes are held in positive contact with the pumping chamber at all times — and their positioning is independent of hydraulic pressure or centrifugal force. Composition carbon graphite bearings and vanes require no lubrication beyond that of the liquid being pumped.**

**All Eastern positive displacement pumps are close-coupled with motor or can be furnished less electric motor with belt stand for belt or coupling drive.**

**Don't make your points the hard way — play safe and write for Eastern's new Bulletin 220 on positive displacement pumps.**

***Other Eastern products:***

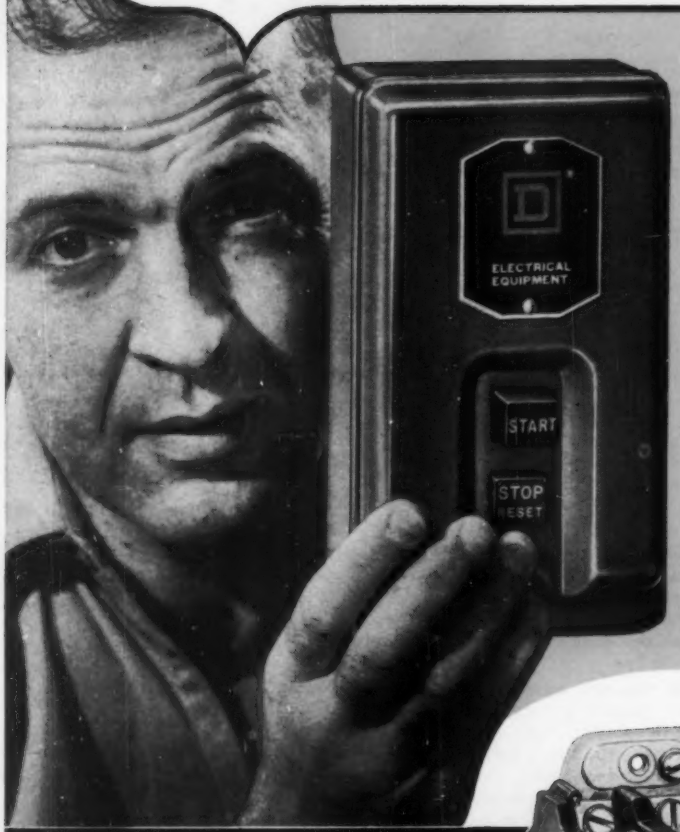
- ***hydraulic motors***
- ***gear pumps***
- ***centrifugal pumps***
- ***aircraft pumps***

EASTERN INDUSTRIES PUMP DIVISION®

# EASTERN INDUSTRIES INCORPORATED

**Hamden, Connecticut**

# This NEW Manual Starter has EVERYTHING!

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**Two, three and four-pole construction**

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- ***SMART STYLING!*** Matches the streamlined appearance of today's modern machines
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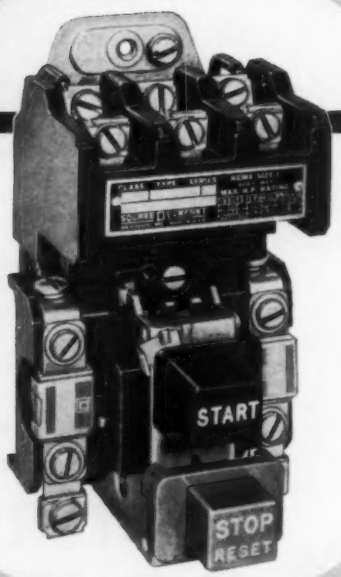
- ***TRIP-FREE OVERLOAD PROTECTION!*** Impossible for operator to hold motor circuit closed against overload
- ***POSITIVE PROTECTION!*** Starter will not operate *without* overload units installed
- ***LONGER LIFE!*** *Toggle Action* operating mechanism. Heavy-duty construction throughout
- ***EASIER INSTALLATION!*** Wire it without removing starter from enclosure. All terminals have pressure wire connectors




- ***EASIER MAINTENANCE!*** "Off-the-Shelf" parts kits make normal maintenance and modifications easier than ever. They're easy to buy, easy to identify, and faster to install
- ***TAMPER-PROOF!*** Cover padlocking device prevents tampering by unauthorized personnel. Safety latch locks "start" button in "OFF" position
- ***VISIBLE INDICATION OF OVERLOAD!*** Self-centering push-buttons show when overload has occurred

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***wherever electricity is distributed and controlled***

# THE ENGINEERING WEEK

## US Industry Breaks Out in Rash of Trade-secret Disclosure Cases . . .

**LENKURT ELECTRIC CO VS GENERAL ELECTRIC CO: plaintiff charges that GE induced three employees to resign from Lenkurt and join GE. Lenkurt says the trio had helped develop its transistorized multiple-carrier system and now GE has the know-how and has signed contracts to produce units. Lenkurt is asking $4 million damages.**

**MERCK & CO VS SEVERAL STAMFORD (CONN) FIRMS AND INDIVIDUALS: plaintiff charges that defendants usurped a secret drug formula and sold the information to competitors here and abroad. Merck is asking $7.8 million damages.**

**ROHM & HAAS VS SAME STAMFORD FIRMS AND INDIVIDUALS: plaintiff charges that defendants took secret information from its files and premises. Attesting that the secrets were developed at great expense, the suit seeks a judgment prohibiting the defendants from destroying any of its records or disclosing the secret information to anyone until suit is settled. Plaintiff wants reimbursement of all profits.**

**RADIATION INC VS ORTONIX INC: plaintiff charged that certain of its former employes (founders of Ortonix) used confidential and secret knowledge, designs, drawings, lists of customers, etc.—all of this having been acquired during employment with Radiation, to benefit Ortonix and themselves. The 9th Judicial Circuit Court (Florida) awarded Radiation a consent decree and damages totaling more than $200,000.**

**SARKAN TARZIAN VS AUDIO DEVICES: plaintiff charged that 8 of its former employes used confidential information belonging to Tarzian after forming their own organization (Audio Devices); Tarzian offered in evidence the agreements signed by 7 of the 8, promising not to disclose trade secrets. Court found for the defendants, declaring that plaintiff failed to prove Audio Devices was using any confidential information belonging to Tarzian.**

**TRACERLAB VS ELECTRO NEUTRONICS: plaintiff charges that two former employes, who formed a firm called Electro Neutronics, pirated secret design and price data from Tracerlab. This confidential information had been developed by Tracerlab under Navy contract but was used allegedly by Neutronics to obtain production contracts to make a radiation-monitoring device for nuclear submarines. Neutronics will argue that the device could not have been developed if Tracerlab hadn't been working under government contract; consequently, the so-called secrets are in public domain. Tracerlab is expected to retort it did all the design work, that Navy still does not possess the complete design.**

## . . . But Courts Walk a Vague Line Between What's Secret and What's Skill

NEW YORK—More and more frequently throughout the industrial US, courts of equity are being asked to decide whether employers are being deprived of valuable property, or if employes' minds are being mortgaged beyond redemption.

For example: a design engineer with a major manufacturer resigns abruptly to join a competing firm. Months later, the former employer brings action against the engineer and his new bosses, charging unfair competition; i.e. fraudulent use of trade secrets. In defense, the ex-employe argues that what he took with him was general knowledge and skill acquired during employment—nothing confidential.

According to Charles Marks, New York patent attorney, the problem is an old one that is rooted deep in early English law. Black's Law Dictionary defines a trade secret as "a plan or process, tool or mechanism, or compound known only to its owners and those of its employes in whom it is necessary to confide." Such confidential material is not to be confused with patented ideas, which are spelled out on legal documents registered with the government. However, laws governing trade-secret disclosures in the US can be just as punitive as for patent-law violations.

In the eyes of the law, a manufacturer's ownership of his technical data is among his most valuable assets, basic to maintaining a competitive position. Losing such property can mean substantial loss in terms of market position—even business failure.

However, the manufacturer has been blessed with ample means for protecting the ownership of his confidential material. One way: restrictive covenants in which the employe agrees not to divulge confidential information during or after tenure of employment. Another is a contract requiring that the employe will not work for a competing firm within a specified geographical radius for a certain period of time. However, courts require that terms of such covenants be reasonable. A frequent limitation acceptable to jurists prevents an employe from competing with his former boss for one year within a 200-mi radius. However, such decisions depend largely on prevailing state laws.

In any commercial enterprise, the problem is bound to arise. Supreme Court Justice Benjamin Cardoza once said: "In most any business organization, the employer at some time must confide in one or more of his employes. If he takes the precaution of advising his employes not to divulge these confidential matters, then the employe is under instinctive obligation not to reveal them."

The written agreement not to divulge trade secrets (usually embodied in an employment contract) is just one way of making certain the employe is aware of his "instinctive obligations." In 1851, a judge ruled: "An agreement by an employe that after expiration of employment he will not use confidential information obtained during employment in competition

with his former employer, and will not furnish such information to others, is a contract in partial restraint of trade. But it will be upheld as valid when it is reasonable in its terms, and necessary for protection of the employer's business."

In substance, if the employer utilizes the available cloaks of secrecy, the employe who subsequently divulges the trade secret and those who benefit from the disclosure will eventually have to pay the piper.

On the other hand, in any court of equity, the offended employer must prove (1) that something was appropriated, (2) that the something was confidential and that the employe knew this, and (3) that the employe obtained this something during his tenure of employment. Anything less could lose the case for plaintiff.

Besides legal covenants, the employer has a variety of ways to enforce secrecy. These include: clearance of all reports and speeches delivered by company representatives; the requirement that confidential information be divulged only to those employes who really need to know; insurance that agreements with other companies stipulate keeping trade secrets in strict confidence, designation of all documents (blueprints, specifications and other paperwork) containing confidential information with a warning legend.

Even without such restraints, an American employe, whatever his position in the company, is under obligation not to use trade data gleaned from his former employer to enhance his position with his new superiors.

A prime example is the 1954 case of Carter Products vs Colgate-Palmolive. Here an employe in a Carter division played a major role in developing a shave cream dispenser called Rise. While with Carter, the employe tried more than once to affiliate himself with Colgate. Only after Rise hit the market, did he succeed in his switch to Colgate, assisted by a good reference from Carter.

Some months later, Colgate introduced an aerosol container for shave cream called Rapid Shave—a product similar to Rise. Carter subsequently brought action against Colgate-Palmolive and the former employe, charging unfair competition. In court, Carter offered in evidence notebooks kept by the employe during his development of Rise. These proved almost identical to the notebooks he later kept for Colgate.

The court decided for Carter, not so much because the aerosol technique was exclusive with Carter, but rather because the employe had violated basic precepts of employer-employe relationships.

But what of the rights of an employe? Is he therefore pretty much shackled to the covenants made with his employer?

One jurist has said that language is inadequate to delineate the respective rights of employer and employe. But one thing is certain—what the employe learns from experience can't be brainwashed away.

True, in some jurisdictions the employe's obligations have been spelled out in specific statutory language. For example, Section 2860 of the California State Labor Code states: "Everything which an employe acquires by virtue of his employment, except the compensation which is due him from his superiors, belongs to these employers whether such acquisitions are obtained lawfully or unlawfully, during or after the tenure of employment."

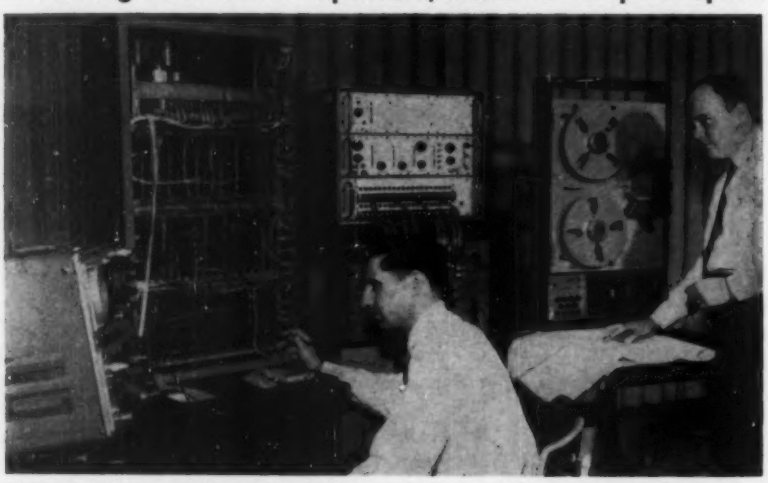
In general, however, courts of equity (most such cases are processed through state supreme courts but there are other legal avenues for redress) hold that an ex-employe has the right to engage in a competitive business for himself and to compete with his former employer if the competition is fair.

In the case of Donahue vs Permacil Tape, the ruling was that a former employe has a right to use all knowledge and information, belonging to him as an individual, for the transaction of any business in which he may engage—just as he may use the skill, knowledge, information or education he had before entering employment.

For example, an unskilled employe who becomes skilled at the expense of one employer is free to move on to a higher paying job even if it's with a competitor. The fact that an ex-employe quits and goes to work for a competitor is not actionable under laws governing nondisclosure of trade secrets; it must be shown that the former employer is suffering unfair competition as a result.

Differentiating between trade skills and trade secrets is no problem when dealing with unskilled employes. But the more important the employe to

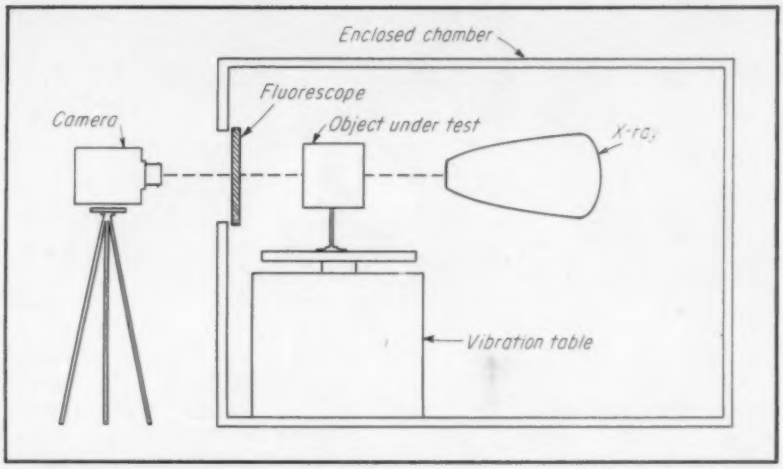
## Unskewing Buffer Stores Tape Data, Increases Computer Speed



**Claiming data-transfer rates as high as 360,000 alphanumeric characters per sec via 16 parallel recording channels on 1-in. tape and at packing densities up to 1500 bits per inch, Potter Instrument Co, Plainview, NY, says its High Density Recording System actually gives higher reliability than is expected of standard recording methods. High accuracy is through use of self-clocking information channels—no separate clock channel is needed and multichannel data are read in parallel form, despite interchannel time displacement. Control buffers store bits and discharge a complete character simultaneously, regardless of order of pickup from the tape. In a 40-hr continuous operation test, less than 2 sec re-read time were required to recover any data lost through transient error, and no permanent loss of information occurred. More than 20,000 passes over any portion of the tape can be made without losing information, or significantly increasing dropout rate.**

the organization, the more difficult to draw the line of distinction—especially for engineers and technicians engaged in research and development. In these cases, it behooves the employer to label specifically and in detail what he considers confidential and make sure that the employe understands what is meant.

Also, when the employe has worked in sensitive areas of the organization and decides to leave the firm, it might be advisable to stage a general review of things confidential—to serve as a double-barreled guarantee for the employer. ■




**TEST OBJECT** and X-ray equipment are placed in an insulated chamber for safety. The camera records an image projected on an image intensifier set in the cell wall.

## East West to Confer on Measurements

VIENNA—Some 700 delegates from more than 22 countries are expected to attend the 2nd International Measurement Conference (IMEKO-1961) in Budapest June 26 through July 1 —nearly double the participation at the first meeting in 1958.

A total of 138 technical papers have been selected so far as suitable for presentation while 150 specialists from 26 countries have expressed a desire to participate actively in the program. The three official conference languages are English, Russian, and German, with French permitted for those who wish to use it.

The conference will deal with fundamental questions of metrology as well as the main trends in development of scientific and industrial instrumentation. The relationship between education and instrumentation will be probed, as will the connection between automation and measurement. In addition, the creation of a common international vocabularly encompassing technical measurement terms will be considered.

IMEKO's preparatory committee (of which the Instrument Society of America is a member) agreed that the Paris International Exhibition scheduled for May 9 through May 17 will not conflict with the Budapest conference. The Paris meeting consists of a conference of 700 foreign and domestic delegates as well as an International Measurement and Instrument Show.

The US is expected to send 20 delegates to the Budapest conference.

—Fred Baer, Regional Editor

**ENLARGEMENTS** from 16mm movie film, this series of frames depicts movement of a counterbalance within a pressure transducer that has failed. Film speed was about 800 frames per sec while the transducer was being vibrated within its operational environment. The failed counterbalance is indicated by the arrow in one frame.

## X-ray Movies Show How Part Works—and Fails

SAN DIEGO, CALIF — Convair-Astronautic's Reliability Group has been using for the past year a technique of X-ray movies to observe operation and failures of encapsulated devices in their operational environment. The assembly to be studied is placed between an X-ray unit and a fluorescent screen within a radiation cell. Rays from the X-ray pass through the object and impinge on a fluoroscope (image intensifier) in the cell wall. Either standard (24 frames per sec) or slow-motion movies can be made.

Borrowed from medicine, this high-speed X-ray method has been in use for several years, notably with Westinghouse equipment at Rototest Labs, Lynwood, Calif. It has been called Cine-radiography and used in life, vibration and performance tests on electronic components. Once the film reveals deterioration or failure of a part, the engineer can X-ray minute sections, using controlled penetration and laminography to focus on the critical point. The camera shutter is electrically synchronized with the X-ray pulses. Stereoscopic methods are

*continued on page 20*

The American Hot Dip
Galvanizers Association
with the cooperation of
The American Zinc Institute
Announces the $10,000.

*Galvanizers' International*

# Ten Awards of $1,000. Each

Ten awards are to be made to entrants selected by the judges. Each award will consist of $1,000 in cash, a suitable medal and a Certificate of Achievement.

*This is not a contest*—it is a search for new ideas. ■ *Your entry, therefore,* will not be judged against others, but solely on its merit and value in developing new applications and markets for Hot Dip Galvanizing. ■ If your idea, in the opinion of the judges, is of practical value to the industry, you will be cited for an award—promptly. ■ Because the Hot Dip Galvanizing Industry is anxious to receive ideas of this type, the judges reserve the right to present *more* than 10 awards, if the entries warrant.

**CONDITIONS** ■ Anyone in the world (except members of the American Hot Dip Galvanizers Association and the American Zinc Institute, and their employees and advertising agencies) may submit one or more entries. ■ Entries will be considered by the judges promptly upon their receipt. No entry received after April 30, 1962 will be considered. ■ The Awards will be made for ideas pertaining to: (a) Applications of Hot Dip Galvanizing to a *new or unusual* field, or; (b) An *improvement* in application in fields where Hot Dip Galvanizing is now being used, or; (c) New methods of *after-treatments* of Hot Dip Galvanized products. ■ Each entry submitted must contain: (a) Description and documentation of application. (b) Case history of the application or process accompanied by photo, drawings, formulae, etc. (c) All technical data needed for the utilization of the idea submitted. (d) Release of the application or idea for general use without payment or royalty other than the $1000 award. ■ The decision of the judges will be final. Award-winning ideas will be retained by the American Hot Dip Galvanizers Association for dissemination throughout industry. Other entries will be returned. ■ No formal entry blank is required but the entry should be accompanied by the name, address and business connection of the individual submitting it. Business firms or corporations may submit entries under their business name, instead of as individuals, if they choose to do so. ■ Entries should be sent to: AMERICAN HOT DIP GALVANIZERS ASSOCIATION, INC., 5225 Manning Place, N.W., Washington 16, D. C. ■ *Note:* For information on galvanizing write to the above address for name and location of the American Hot Dip Galvanizers Association member nearest you.

*Awards*

FOR ACHIEVEMENTS IN RESEARCH, DEVELOPMENT AND UTILIZATION OF GALVANIZED PRODUCTS

**THE JUDGES** ■ Dr. Clarence H. Lorig, Technical Director, Battelle Memorial Institute and Past President American Society for Metals. ■ Mr. John R. Daesen, Technical Director, American Hot Dip Galvanizers Association. ■ Mr. John L. Kimberley, Executive Vice President, American Zinc Institute.

*continued from page 17*

being considered, as well as correlation with closed-circuit TV and other test equipment.

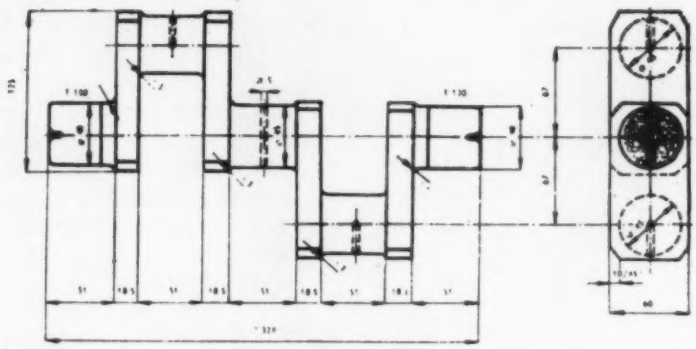
As used at Convair, the object being photographed can be on a vibration table, under heat or vacuum, or subjected to other single or combined test or working environments. Pictures are, of course, of a projected "shadow," so the individual frame is not clear, but the projected movie is readily understandable. Typical tests, so far, have included those of a pressure transducer and of a gear train. One film shows failure of a counterbalance within the transducer; the other shows contact areas on the gears. In each study the pictures were taken through package walls of ½ in. Al.

The X-ray machine, a 150-kv, constant-potential, fractional-focus, Norelco X-ray tube; the assembly being studied; and the environmental equipment are placed within an 8-by-10-ft cell to protect operators against radiation. A fluorescent screen is set within the window in the cell; the camera, a Fairchild motion analyzer, is set up outside. Over the camera opening to the cell is a protective slide which can be shifted to one side for the period of the filming. ■

## Czech Resistance-welding Points to Economy Car Engine

VIENNA, AUSTRIA—Resistance-welded crankshafts made from machined rods and bars may lead to less expensive automobile engines without sacrificing mechanical strength. At least, that's the hope of the Welding Research Institute of Bratislava, Czechoslovakia, which is working on several prototype units, under the direction of Dr Ing O Puchner.

Resistance welding of crankshafts is said to be especially suitable for shafts of less than 1.950-in. dia. A recent test unit made up of four webs and five pins (sketch, right) had this diameter prior to welding. The 0.195-in. dia holes were drilled through the pins after welding to simulate notch effect of lubrication ports. Carbon steel with a tensile strength of 71,100 psi formed the pins and the webs used a 52,600-psi material.



**WELDED CRANKSHAFT:** shape and dimension.

Welded units were subjected to fatigue tests under alternating torsion stresses. Results were compared with data obtained by subjecting forged crankshafts—made for Tatra cars—to similar tests. Only difference between the test shafts was strength; welded shafts averaged 71,100 psi and forged shafts, 99,150 psi.

Higher strength of the forged shaft was originally thought to be an advantage. But, failure tests showed conclusively that the major stress is not in the weld area but in the plane of the lubrication ports.

Vicker hardness numbers ranged between 130 and 214, with the highest hardness value corresponding to the pin-side portion of the weld. Heat treatment of welded crankshafts is therefore necessary. The weakest point as far as fatigue is concerned is the transition from pin to web. Local strain-hardening of the transition area by roller burnishing is found to be an efficient way to improve the fatigue limit and to eliminate web failure. Such strain-hardening can only be efficient if the fatigue limit is not reduced for other reasons.

In crankshafts with lubrication ports, local strain-hardening of the pin-to-web transition has only limited significance unless the notch effect of the lubricating ports is also suppressed. For instance, with specimens in which the webs had intentionally been made from a material with comparatively low static strength, the failures developed in the pins from the lubricating ports.

–F H Baer, Regional Editor

## Keep Math Practical, European Engineers Say

PARIS—Mathematics has become so important to engineers and physicists that their basic training in the subject should be taken out of the hands of mathematicians. This apparent paradox was advanced recently at a seminar here on mathematical knowledge needed for a technical career. The gathering was sponsored by OEEC's Office for Scientific and Technical Personnel.

Mathematics, the delegates agreed, has a dual nature: it is a powerful working tool for engineers, and it is the best of all possible abstract worlds for mathematicians. Most speakers urged that elementary-school teachers keep math concrete, rather than emphasize its abstract qualities. They recommend the same even at the undergraduate level, where new topics, they said, should be introduced by showing their use as tools in science and engineering. Exercises should be drawn from practical applications. Only after that, the consensus held, do students need the rigorous proofs that become the intellectual sustenance of mathematicians. One speaker suggested that differential equations be taught as a laboratory course.

The participants also agreed that engineers and physicists should master similar mathematical disciplines. The requirements include vector field theory, linear algebra and matrices, complex variables, ordinary and differential equations, special functions, probability and statistics. Modern topics should be added to this classical program only when they have engineering applications—as, for exam-

ple, the applications of discrete mathematics to calculating machines.

But no matter how far an engineer advances into mathematics, he should always be kept aware of the quantitative aspects of his subject and the value of numerical methods, the delegates concurred. One speaker pointed out that many engineers run into design trouble because their mathematics instructors, blinded by the fascination of elegant solutions, don't teach them that an integral or differential equation can be solved numerically. Unable to solve, say, a differential equation by analytic methods, they simplify their problems, then run into trouble. The engineers are often unaware that the original problem could have been solved by numerical or graphic methods.

When a tight curriculum forces a choice between deep understanding of mathematics as a working tool, or a superficial covering of many mathematical specialties, the delegates preferred depth of understanding. ■

## Italy's Machine-tool Makers Aim for an R & D Center

MILAN—Italy's machine-tool makers want to set up a research and standardization center to serve the needs of their industry. Though they have a constitution, they face the prospect of a 3-year wait for a completed building.

Traditionally, research in Italy's machine-tool industry has been conducted by individual firms, a costly and fragmentary approach. The association, organized under the name of the Association of Machine Tool Manufacturers, is the first such association of small and medium manufacturers to be formed in this country; other research institutes here are born of cooperation among big industry and state-run industries.

But the association must first overcome two obstacles: (1) availability of funds, and (2) qualified research workers. This may take more than three years.

Administration of the new center is expected to cost about $5000 (no mean sum here) with the National Research Council picking up about half this tab, the association paying some and the rest of the total met by firms that benefit from use of the center's facilities. ■

## MHD Generator Passes High-power Test

EVERETT, MASS.—Having demonstrated the feasibility of magneto-hydrodynamic power systems, Avco has now built and operated a high-power (200 kw) unit. Operating time is not long—only about 10 sec. But that's more then enough, says Avco, to evaluate the system.

Next step will be low-power, long-term testing of various components—with a large-scale version of the high-power unit as ultimate goal. Avco is now convinced that such a system could be at least 40% more efficient than conventional powerplants, right from the start. Thus, MHD plant will operate at the 56% efficiency level.

Many problems remain to be solved. Electrode design needs improvement. Materials must be developed for gas channel walls. New preheating and regenerator systems must be tested. But Avco believes it's now well on the way to solving these problems.

While operation of the large-scale experimental MHD generator will lead the way to development of even larger generators, research is continuing at Avco-Everett on other aspects of the program. One aim is to define the most efficient and practical generator system. It now appears that the first working MHD powerplant will be a fossil-fueled, open-cycle system, but continued development of nuclear power sources means that closed-cycle nuclear-fueled plants are possible.

Other aspects under study are schemes for converting the generator's dc output to ac. At present, simple inverters seem most feasible, but some consideration has been given to making the generator produce dc directly.

The research is being done at the Avco-Everett Research Laboratory with American Electric Power Service Corp as agent for 12 utility companies. ■

## Japan Selling Compact Car with 84.6-in. Wheelbase

TOKYO—A new small passenger car with a 35-hp rear engine and a max speed of 65 mph has been introduced by Hino Motors Ltd, a firm which until this month made the Japanese version of Renault. Called the Contessa, the new model measures 182 in. long, 58 in. wide and 55.7 in. high, with an 84.6-in. wheelbase. The $1625 Contessa weighs 1587 lb.

Hino is also introducing a small front-engine-drive truck capable of loading 1653 lb. The Briska measures 151.6 in. long, 63.7 in. wide, 63.9 in. high, with an 87.7-in. wheelbase. It is priced at $1105. ■

**200,000 WATTS of power can be produced by Avco's largest and most advanced experimental MHD generator. The Mark-II is being used to evaluate engineering problems connected with power generation using MHD's plasma method. Generator consists of iron pole-pieces and copper plates connected to form a coil. The magnetic field is formed across a channel running through center of the magnet. A gas burner similar to a rocket engine produces a 5000-F electrically conducting gas, which is forced through the magnetic field to generate an electric voltage. The power is tapped off on electrodes attached to the inside of the channel and delivered to the load through two sets of cables (upper left). The gas exhausts into the atmosphere through a pipe (lower left).**

# new-lube-free...

STERLING
Sealed and shielded bearings require no lubrication.
Keys are fabricated from tough elastic material to eliminate key and keyway wear.
Wear-resistant non-metallic bushings require no lubrication.
Shaft surfaces are corrosion-proof and require no lubrication.
CAUTION

# ..Sterling's variable speed drive never requires lubrication

**Costs Reduced**—One of management's biggest headaches has been the development and maintenance of proper lubrication schedules. As a consequence, lubrication problems have long been the cause of variable speed drive failures, pulley wear, sticky pulleys, shortened belt life, excessive noise, and many other equally costly problems.

High labor costs, coupled with increased maintenance needs, are major management problems.

**Lubrication Eliminated**—Now, Sterling has eliminated all lubrication maintenance problems. No part of a Sterling variable speed drive needs to be lubricated.

All bearings, sealed and shielded, are factory-lubricated and therefore require no lubrication. Shaft surfaces are impregnated with a special exceptionally tough and wear-resistant material which eliminates need for lubrication. The non-metallic bushings are also fabricated from a special material that is equally wear-resistant.

**Special Load-Bearing Surfaces**—At no time do these surfaces require any attention. Even the keys are fabricated from a tough elastic material and will not wear out.

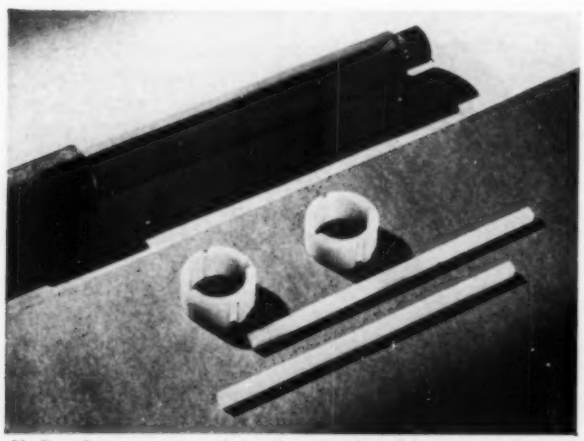
Fret corrosion, long a problem with metallic load-bearing surfaces, is completely eliminated since non-metallic surfaces now carry the load. Sticky pulleys, frequently the result of improper lubrication, are no longer a problem.

Sterling's new "Lube-Free" variable speed drive can be installed in any location, no matter how inaccessible, since lubrication maintenance is no longer needed.

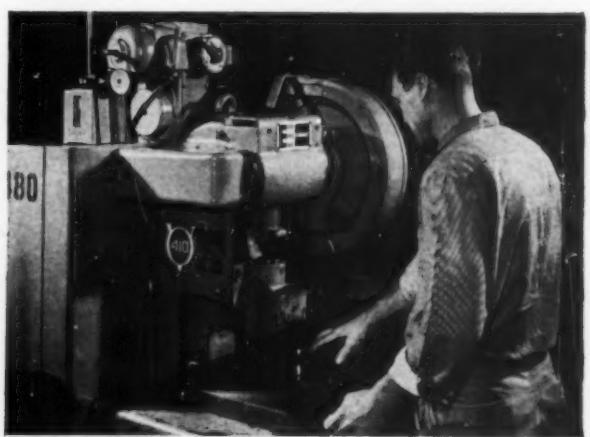
**Other Benefits**—Costs are reduced, money saved, when lubrication maintenance is no longer necessary. Belt life is lengthened; pulley wear is eliminated. Bearing life may also be lengthened by the elimination of worn pulleys—often the cause of vibration and bearing wear.

All other Sterling variable speed advantages are present in this new "Lube-Free" drive: wide range of speeds, heavy duty cast iron case, finger-tip speed control, etc.

**Information Available**—Complete application and product information is available by writing Dept. **B-6,** Sterling Electric Motors, Inc., 5401 Telegraph Road, Los Angeles 22, California—or by contacting the Sterling field engineer in your area.



Shaft surfaces are extremely tough; material provides unusual chemical resistance and anti-frictional properties that make an excellent load-bearing material operating under extremely low or high temperatures. Keys and bushings are fabricated from a material proven to have outstanding abrasion resistance; holds up indefinitely under frictional conditions, thus eliminating need for lubrication.



This V & O Notching Press is powered by a new Sterling "Lube-Free" variable speed drive. It will never need lubrication. Similar units have been installed in the food processing industry. The elimination of lubrication is particularly important in the food processing industry where variable speed drives have such wide application, and where oil and grease create sanitation problems.

Hathaway INSTRUMENTS INC.

**Sterling Electric Motors, Inc.**

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# POINTS OF VIEW

THE QUESTION:

## *What Technological*

### "Conventional-flight problems still persist . . .

despite the rapid transition of the Space Age. The reports of airline crashes caused by operational circumstances at takeoff and landing, air-traffic control in congested areas or structural failures due to speed, emphasize our need to apply ourselves to these more mundane technological problems.

"Thomas Edison's statement that the airplane is 'only half invented as long as it requires a long takeoff and landing run' highlights the problem area. There are more accidents attributable to takeoff and landing than to any other cause, in both commercial and military areas. The takeoff and landing problem will remain of major importance until we eliminate the necessity for aircraft to approach and touch down at speeds which are double the velocity of a hurricane. These speeds can be eliminated by further study and the development of operational V/STOL aircraft.

"Research and development during the 1950s has conclusively demonstrated that many types of conventional propeller and jet aircraft can be successfully developed to operate from vertical takeoff. Regrettably, the dilution of funding by the dawning Space Age and a lack of decisions on operational requirements has prevented follow-on development. This development of the V/STOL airplane offers the industry opportunity for considerable gains. Such

**James A O'Malley Jr**
Aerospace Marketing Dept
Bell Aerospace Corp

gains can only be accomplished by building second-generation V/STOL aircraft. In transport and fighter-bomber applications, these aircraft can be placed in the field on an operational basis. These operational aircraft will quickly develop to suit uses and capabilities antiquating our present methods of takeoff and landing. This joining of the technological capabilities of the machines with the experience and ingenuity of our operational groups is the only means of guaranteeing successful development.

"An ambitious triservice V/STOL transport is being initiated. This program, properly funded and aimed at a state-of-the-art increase over conventional rotary-wing aircraft, will provide many of the operational inputs needed for successful development."

### "Two research projects come to mind . . .

both of which will require extensive investigation and which could be very important if positive solutions can be found. One is the development of materials which will do the job at elevated temperatures (above 450 F) that the organic elastomers, sealants, and adhesives can do today. A materials system which has the temperature resistance of the silicones, but the strength of the conventional carbon chains, would offer a simplification of design and a very real cost saving even if the materials themselves were expensive.

"Certain organic materials are available which do retain their properties after short-time exposure to temperatures up to 2000 F; however, for applications in aircraft which will operate at Mach 3 and faster for periods up to 2000 hours, presently available organics fall far short of practical application. Development work on new polymers such as the organometallics to improve this life at temperature and to reduce the effects of high-temperature oxidation may prove fruitful.

"The second needed development is that of learning the fundamental mechanisms which cause or influence crack-propagation or tear-resistance characteristics of metals. Empirical work has shown that this characteristic will frequently limit the utilization of the high tensile and compressive strengths which can be obtained in currently

**F R Kostoch**
Group leader
Material and Process
North American Aviation Inc

available alloys. In general, as the strength level of metals is increased, the crack-propagation tendency is also increased, i.e. the length of crack which will be self-propagating becomes shorter and shorter as the strength level goes up. Increased strength level is recognized as not being the whole story because not all structural metals react to the same degree. Thus, in two different alloys, the stronger material may have better resistance to crack propagation. In some cases, there are observed anomalies, where the soft (annealed) condition is less tear resistant than is the hardened condition. Knowledge of the fundamentals could lead to design of alloys or to the control of constituents in current alloys in such a way that users could take full advantage of high-strength metals."

# *Problems Need Solutions in the Aircraft Industry?*

**"The free world needs many scientific advances . . .**

during the next several years if it is to hold the lead in the international race for aeronautic and astronautical supremacy. These needs have been stressed in a report prepared by more than 200 research and engineering experts. Of particular interest to those concerned with product engineering are predictions that:

- There will be an ever-decreasing time for manufacturing development, a byproduct of ultramodern weapon systems as a result of scientific and technological gains.
- During the next five years, the required high-yield alloys (to 350,000 psi) will be available only in sheet and bar form. To minimize rising costs, sheet-forming equipment being developed will have to produce parts closer to final configuration.
- When higher temperatures are used to process refractory-metal alloys the industry will be confronted with entirely new materials problems. High vacuum, high temperature furnaces must be developed for heat-treating high-melting-point, atmosphere-sensitive materials.
- The use of conventional cutting equipment is declining, particularly in environmental problem areas. Some operations such as shearing, blanking, and machining presently performed at room temperatures will have to be done with tools and materials at very high or subzero temperatures.
- Applications of numerical tape control will extend rapidly to lofting, drafting, testing, inspection, and system checkout.
- Many methods of joining materials are being upgraded as greater joint-strength requirements become manifest during the next decade. Assembly of components into lightweight, fuel-tight structures will put increasing emphasis on fusion, rather than resistance-welding processes. A method of joining metals without heat is needed, and welding of fibrous materials used for transpiration cooling must be investigated. Techniques are also sought for welding refractory metals to dissimilar metals, and for welding metals to glass.

**Gen Orval R Cook**
President
Aerospace Industries Assoc

- Techniques and equipment will have to be developed for special handling and storing of many materials. Wide, extremely thin sheet material must be transported without deformation. Exhaust and filtering systems will be widely needed to reduce health hazards in processing toxic materials, such as beryllium. Any use of radioactive materials will require special automatic remote-control machines, controls for chips and coolants, insulating materials, measuring methods and waste-disposal equipment."

**"Microbes that contaminate fuels will clog . . .**

the fuel filters, cause faulty capacitance fuel-gage readings and corrode fuel tanks. Kerosene-type fuels nourish a variety of bacteria and fungi that thrive in the condensed water vapor trapped in jet-aircraft fuel tanks. A warm, humid climate affords the necessary environment for rapid growth of these microorganisms. It's called 'green slime' which adequately describes its sinister character; but actually the residue is neither green nor slimy. It appears as a black, tar-like scum when wet and as a light tan-gray powder when dry.

"On December 2, 1960, the Aircraft Research and Testing Committee of the Aerospace Industries Association met at Orlando, Fla, and established a project to bring coordinated aircraft-industry action to bear on finding a solution to the green slime problem. Concern of the aircraft industry has been heightened by the new corrosion problem which has only been known during the past few months.

"The US Naval Research Laboratories have identified the microorganism types and determined that growth occurs at the fuel-water interface. They have found that growth is nourished by hydrocarbons taken from the fuel and by oxygen from the water. The ideal solution is to find a fuel additive that prevents bacteria growth, is harmless to fuel-tank interiors and does not affect fuel-combustion characteristics. Research has solved such problems in the past and the aircraft industry looks again to research to rid our fuel tanks of green slime."

**Edward H Spaulding**
Chief technical engineer
California Div
Lockheed Aircraft Corp

# NEW SUPER-TOUGH ORE HAULER USES

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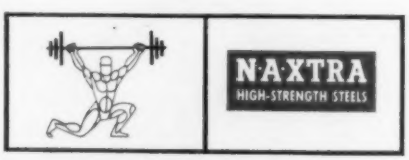
## TO CUT DEAD WEIGHT AND STRETCH PAYLOAD CAPACITY

This Lectra Haul M-55, made by Unit Rig and Equipment Co. of Tulsa, is now working in the open pit iron mines in Minnesota's Mesabi range. In bone-freezing —40° weather, it can stand up to the shuddering shock of 55 tons of drop-loaded iron ore, climb a 6% grade at 8.6 mph then dump those 55 tons in a crashing, grinding 18 seconds. The quarry body that takes this loading impact and dumping abrasion in sub-zero temperatures is made of N-A-XTRA high-strength steel, with X-A-R Abrasion Resistant Steel for extra hardness and toughness in wear areas. N-A-XTRA also forms the structural members of the complete unit.

Why N-A-XTRA? Because, pound for pound, it's nearly three times stronger than ordinary steel. That means it's strong enough to absorb severe punishment without constant maintenance, and light enough to handle the highest possible payload. In fact, the Lectra Haul payload is almost as much as the net vehicle weight itself.

N-A-XTRA and X-A-R are doing the job where only the strongest steels will do. Easily formed and welded, they are making products stronger, lighter, longer lasting. N-A-XTRA fully quenched and tempered steel is available in four levels of minimum yield strengths, from 80,000 to 110,000 psi. X-A-R steels are supplied in hardnesses from 360 to 400 BHN (or, by agreement, in a range between 265 and 500 Brinell). For full technical information, write Great Lakes Steel Corporation, Product Development, Dept. PE-1, P.O. Box 7310, Detroit 2, Michigan.

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| O'Neal Steel, Inc.<br>Birmingham, Alabama | Salt Lake Hardware Co.<br>Salt Lake City, Utah | A. C. Leslie & Company, Ltd.<br>Montreal, Canada |

*Lectra Haul M-55; made by*
*Unit Rig and Equipment Co., Tulsa, Okla.*
*224,000 lbs. GVW*
*110,000 lbs. capacity*
*700-hp. diesel engine*
*4 wheel-mounted electric traction motors*

*Design note: Bottom, sides and front of the Lectra Haul quarry body were fabricated of N-A-XTRA 100 (100,000 psi minimum yield strength) from plates ½" thick and reinforced with cold-formed channels of ⅜" thick N-A-XTRA 100. Wear areas of bottom, side and front slopes were made of X-A-R Abrasion Resistant Steel from plates ⅝" thick, 388 Brinell hardness. Fabrication followed standard shearing, gas cutting and welding procedures.*

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*Great Lakes Steel is a Division of* **NATIONAL STEEL CORPORATION**



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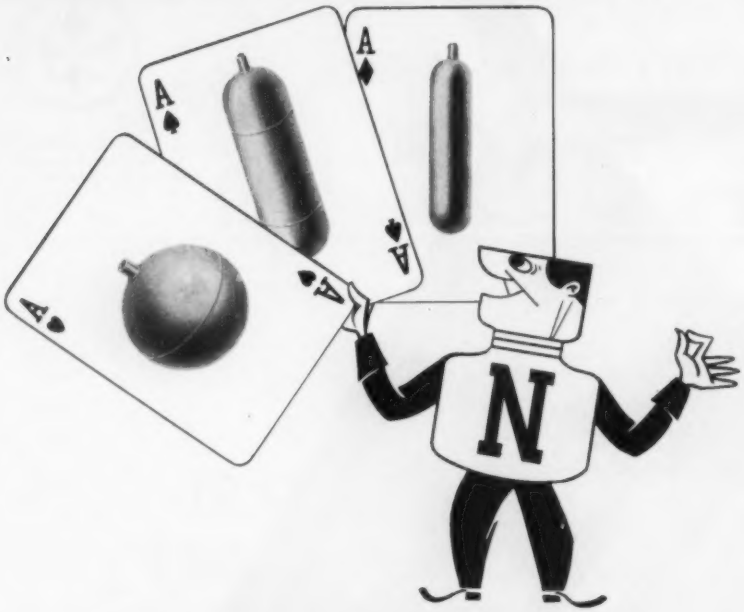
# Nicholson Welded Floats . . .

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Our 80th Year


## READER TO EDITOR

### More on Safety Belts

*To the Editor:*

It was in 1958 that Cornell Medical College, through its crash-injury research program, estimated that if every car on the American highways were equipped with the then 2-year-old safety devices, the 40,000 deaths a year due to car accidents could be cut to 19,000. Five years earlier, in 1953, Ford had become interested in the Cornell program and in 1955 we made our first contribution to the work of this group.

The most spectacular discovery of this group was that passengers and the driver were far safer if they remained in the car than if they were thrown clear. Ejected occupants, Cornell found, suffered more than twice the injury risk and were fatally injured five times as often as those who stayed inside. The program also established the steering-wheel post was the greatest injury source inside the car, with the instrument panel a close second and shattering of the rear-view mirror a contributor.

When these facts were established, Ford engineering speeded a top-priority program aimed at "packaging the passenger" against the more serious hazards. The result was the famous Ford 1956 safety package: safety door latches to reduce the danger of doors opening, high-test seat belts, deep-dish steering wheels, improved padding on instrument panels and sunvisors and shatter-resistant rear-view mirrors. We spent more than $10 million in development, and we spent many many millions on safety as our basic advertising theme. Our crusade got off to an excellent start, probably due to a pent-up demand for safety features among those whose bitter experience had made them safety-conscious; then the demand slackened. The general public remained indifferent.

There are three basic elements in safety: the driver, the highways, and the car. We are amazingly good drivers, on the average, yet there will always be drivers unfit to use our highways. The legislator who lays down strict physical and mental requirements for licenses deserves our support, and so does the conscientious patrolman or judge who deals with the chronic speeder and the accident-prone or alcohol-prone driver. Our highways are good; our highway engineers have done a superb job trying to catch up with the World War II lag in construction. However, no highway engineer can build a road safe for all cars at all speeds—which brings up the factor of car design.

The modern American car is a massive shield of steel, powered by a motor capable of quick acceleration for merging with fast-moving traffic streams, or for crossing them safely. Power, however, is not the primary cause of accidents. Over half our serious accidents occur at speeds of less than 45 miles an hour. Our 1956 efforts in the field of vehicle safety were spectacular and the ensuing years have

seen no relaxation of our safety research. The development program continues at full throttle. The company cooperates with every legitimate highway and traffic safety organization to improve highways, reduce accidents and lessen the severity of accident-incurred injuries. Our laboratories currently stage, on the average, two crashes per month to study the effect of new safety devices on anthropometric dummies, and to aid in the design of even more effective protective items.

—R H Fredericks, *supervisor*
*Vehicle Safety and Accessories Section*
*Product Study Engineering*
*Ford Motor Co*

## CORRECTIONS

. . . We regret that through oversight we failed to give suitable credit for material in our article, "For Stronger, Tougher Metal-powder Parts," (Mar 13, p 78). Supermet Div of Globe Industries was our source, particularly of the mechanical-property data and photographic material.—Ed.

. . . In the article "When Linkages Need Harmonic Analysis" (Mar 6, p 47), the last term in the working equation should have been cos $m\theta$ instead of cos $m$.—Ed.

. . . In my article, "New Equations Simplify Pin Measurement of Gears," (Mar 13, p 80), inv $\phi_t$ should be inv $\phi A$ in Eq (2). The term "sec $\phi_n$" in Eq (4) and (5) should be deleted.

John H Glover
*Ford Motor Co, Detroit*

## COMING EVENTS

### MARCH

**27-31** . . . . Instrument Society of America, National Bureau of Standards, American Institute of Physics, Temperature Measurement and Control, Veterans Memorial Building, Columbus, Ohio

### APRIL

**4-7** . . . . Society of Automotive Engineers, National Aeronautic Meeting and Missiles and Aircraft Engineering Display, Commodore Hotel, New York

**5-7** . . . . Institute of Environmental Sciences, Annual Meeting and Equipment Exposition, Sheraton Park Hotel, Washington, DC

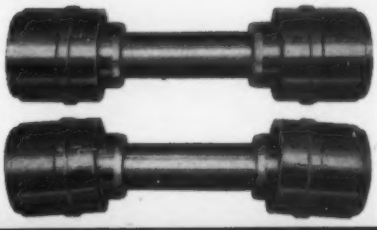
**11-13** . . . . American Society of Lubrication Engineers, Annual Meeting and Exhibit, Bellevue-Stratford Hotel, Philadelphia

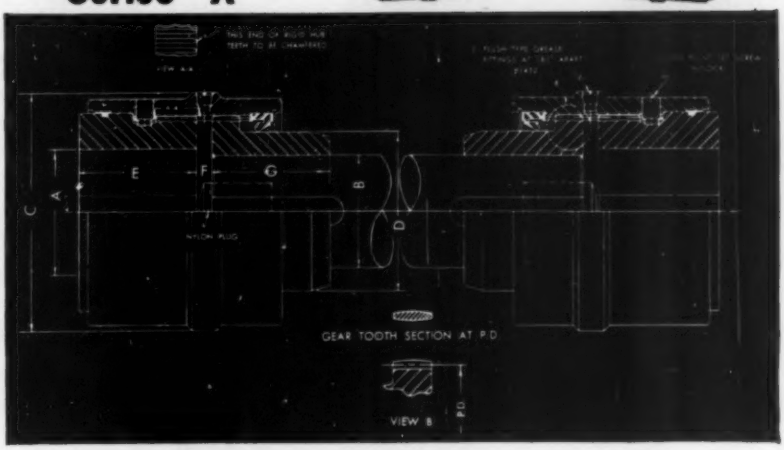
**20-21** . . . . Society of the Plastics Industry, 18th Annual Western Section Conference, Hotel del Coronado, Coronado, Calif

**For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.**


design facts . . . on

WALDRON
High
Misalignment
Series "X"






| COUPLING SIZE | H.P. PER 100 R.P.M. | MAX. BORE RIGID HUB A | MAX. BORE GEAR HUB B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|
| 1¼X | 3½ | 1⅜ | 1¼ | 3¾ | 2 | 2⅛ | ¼ | 2 |
| 2X | 12 | 2⅛ | 2 | 4 17/32 | 2⅞ | 2⅜ | 5/16 | 2¼ |
| 2½X | 26 | 2¾ | 2½ | 5 9/16 | 3⅝ | 2¾ | ⅜ | 2¾ |
| 3X | 50 | 3⅜ | 3 | 6 11/32 | 4¼ | 3¼ | 7/16 | 3¼ |
| 3½X | 86 | 4 | 3½ | 7⅜ | 5 | 3¾ | 7/16 | 3¾ |
| 4X | 130 | 4½ | 4 | 8 7/32 | 5¾ | 4¼ | ½ | 4¼ |
| 4½X | 210 | 5¼ | 4½ | 9 7/16 | 6½ | 4¾ | ½ | 4¾ |

The Series X coupling is specifically designed for transmission of power in applications where shaft misalignment is too great to be handled by a standard gear coupling.

Each coupling assembly has two rigid hubs, mounted on drive shaft and driven shaft, each connected to a one piece sleeve by a spline used for driving purposes only. This spline extends only a portion of the hub length, and the remaining length of the hub is a turned surface which fits snugly into the counterbore in the sleeve to provide a suitable bearing surface. These two sleeves are connected by a floating shaft on both ends of which are mounted flexible hubs with gear teeth of unique design which permits misalignment up to 5°.

Series X couplings are easy to dismantle and reassemble. By backing off the set screws, the sleeves can be disengaged from the rigid and flexible hubs. Specially designed seals and steel protecting rings are held in place in the sleeves with Spirolox rings. End portions of the gear hubs are tapered for easy reentry of the seal in reassembly.

All load carrying parts are machined from high strength alloy steel. Floating shafts to customer specifications have nylon plugs inserted in each end to limit axial float and to prevent damage to the lathe centers of the roll shafts.

*Write for Catalog*

WALDRON Couplings
MTR

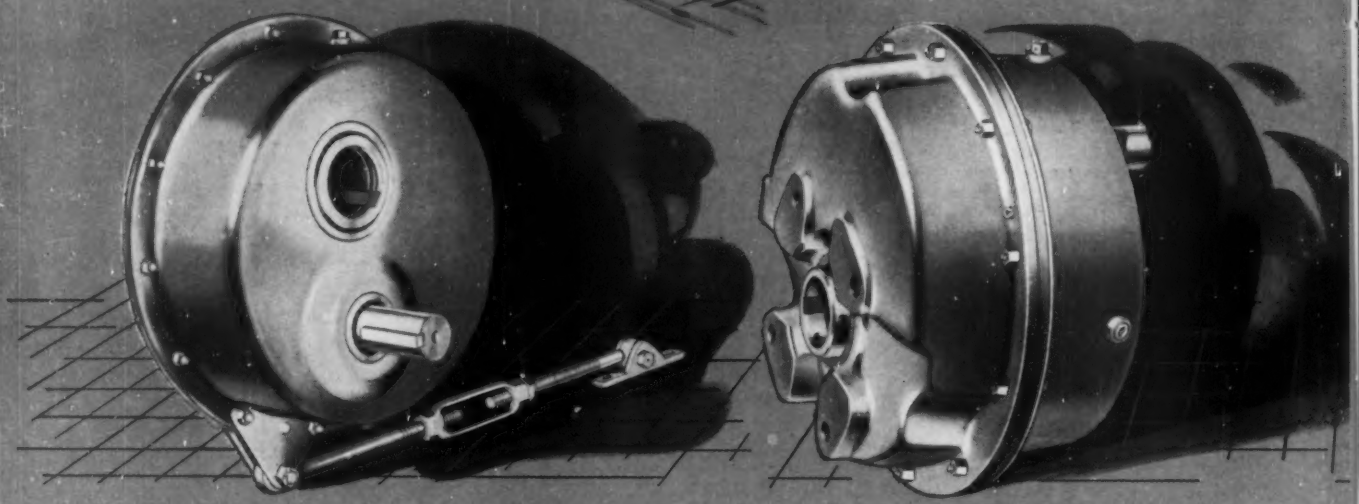
WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
BOX 791, NEW BRUNSWICK, N. J.
SALES REPRESENTATIVES FROM COAST TO COAST

CIRCLE 29 ON READER SERVICE CARD

CIRCLE 30 READER SERVICE CARD→

# FALK

## A GOOD NAME IN INDUSTRY



*Ask for Bulletin 7100*

*Ask for Bulletin 7100*

## *147 COMBINATIONS . . . horizontal or vertical applications . . . . .*

| UNIT SIZE | SHAFT MOUNTED DRIVES | | | | | |
|---|---|---|---|---|---|---|
| | RATIOS | | | MOTOR MOUNT | OVERLOAD RELEASE | BACK-STOP |
| | 4 | 14 | 24* | | | |
| 107J | X | X | X | X | X | X |
| 115J | X | X | X | X | X | X |
| 203J | X | X | X | X | X | X |
| 207J | X | X | X | X | X | X |
| 215J | X | X | X | X | X | X |
| 307J | X | X | X | X | X | X |
| 315J | X | X | X | X | X | X |
| 407J | | X | X | X | X | X |
| 415J | | X | X | X | X | X |
| 507J | | X | X | X | X | X |

½ to 125 hp. Up to 100,000 lb-in. torque

| UNIT SIZE | FLANGE MOUNTED DRIVES | | | | | |
|---|---|---|---|---|---|---|
| | RATIOS | | | | BACK-STOP | MOTOR MOUNT |
| | 4 | 9 | 14 | 24* | | |
| 107J | X | X | X | X | X | X |
| 115J | X | X | X | X | X | X |
| 203J | X | X | X | X | X | X |
| 207J | X | X | X | X | X | X |
| 215J | X | X | X | X | X | X |
| 307J | X | X | X | X | X | X |
| 315J | X | | X | X | X | X |
| 407J | | | X | X | X | X |
| 415J | | | X | X | X | X |
| 507J | | | X | X | X | X |

*20:1 ratio for sizes 107 and 115

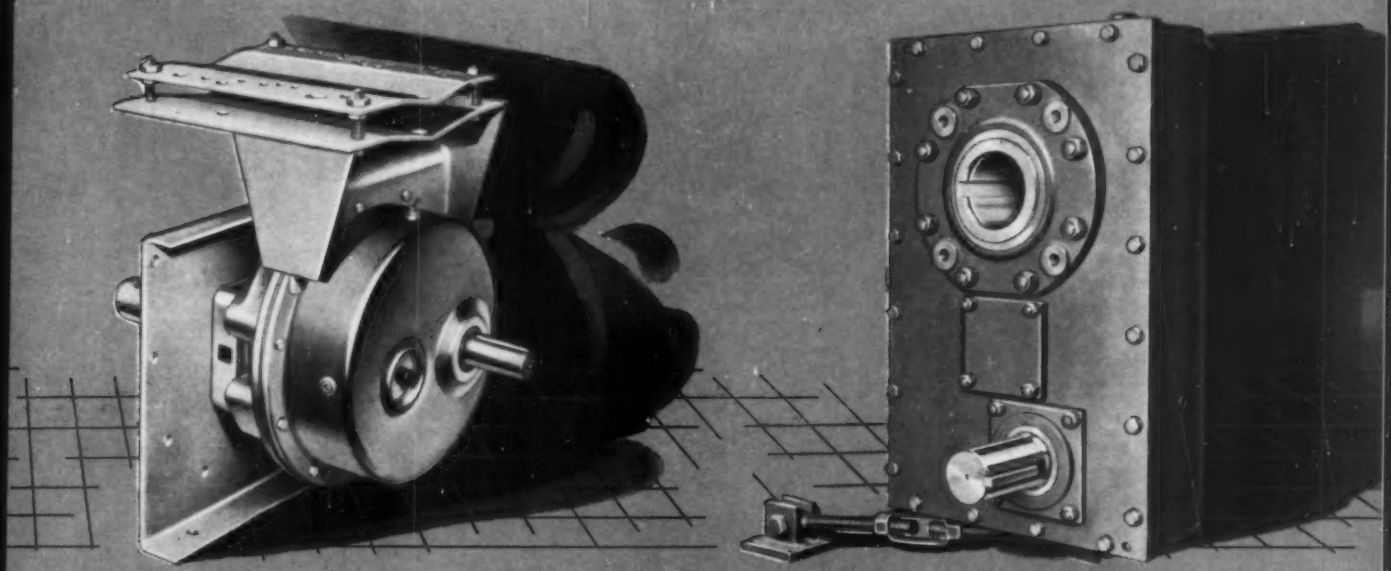
½ to 125 hp. Up to 100,000 lb-in.

***Exclusively* FALK...*Adaptability of all these three types of Falk Drives for use with Equi-Poised Motor Mount.* This feature reduces costs of engineering and constructing motor bases and foundations.**

***Exclusively* FALK...*Interchangeable rotating elements* size-for-size between Shaft and Flange Mounted Drives or Screw Conveyor Drives. This feature simplifies stocking and maintenance for large users.**

# . the most complete line of SHAFT MOUNTED, FLANGE MOUNTED and SCREW CONVEYOR drives . . .

***The line with the exclusive EQUI-POISED motor mount***



*Ask for Bulletin 7106*

## . . . AVAILABLE FROM STOCK

| UNIT SIZE | SCREW CONVEYOR DRIVES | | | | |
|---|---|---|---|---|---|
| | RATIOS | | | | MOTOR MOUNT |
| | 4 | 9 | 14 | 24* | |
| 107J | X | X | X | X | X |
| 115J | X | X | X | X | X |
| 203J | X | X | X | X | X |
| 207J | X | X | X | X | X |
| 215J | X | X | X | X | X |
| 307J | X | X | X | X | X |
| 315J | X | | X | X | X |
| 407J | | | X | X | X |
| 415J | | | | | |
| 507J | | | | | |

½ to 40 hp. Up to 44,000 lb-in. torque

*Exclusively* **FALK**... *Single helical gears* used in *all* sizes and types—they provide maximum (98½%) efficiency per gear mesh.

FALK is a registered trademark

## New 2 LARGER SIZES OF SHAFT MOUNTED DRIVES—415-507

**Falk-designed and Falk-built for higher torque requirements, these all-steel, *helical* gear reducers are available in Shaft and Flange Mounted Drive design.**

**TWO RATIOS, 15:1 and 25:1**
**HORSEPOWER RATINGS TO 125**
**TORQUE RATINGS TO 100,000 LB-IN.**

***Ask for*** **Bulletin 7100.1 (Shaft and Flange Mounted Drives) or for Bulletin 7106.1 (Screw Conveyor Drives).**

**THE FALK CORPORATION**
**MILWAUKEE 1, WISCONSIN**

***Manufacturers of Quality Gear Drives and Flexible Shaft Couplings***

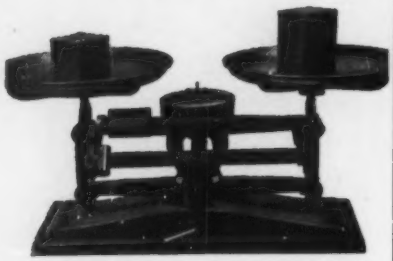
**Representatives and Distributors in most principal cities**

---

**A POINT TO PONDER**..when you need gear drives or shaft couplings of "FALK OR EQUAL" quality, where but from Falk can you get the "OR EQUAL"?

# KENNERTIUM*

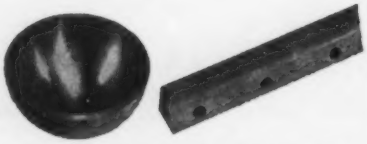
## ...a new alloy 50% heavier than lead



Both blocks on the scales weigh the same. However, the lead block on the right occupies 50% more space than the cube of Kennertium at the left.

Usually, when high density or concentrated mass is desirable . . . small volume is, too. Ballasts and counterweights for missiles and jet aircraft, for example, must often fit very small areas. For these and many similar applications, Kennertium—a special blending of tungsten and other elements—is now being used.

In the above photograph, the block on the left is Kennertium . . . the one on the right is lead. For equal *volume*, Kennertium provides 50% more weight than lead. The high specific gravity of the material makes it particularly suitable for counterweights on the wings and empennage of aircraft (below right).



Used as a radiation shielding material, Kennertium (containing over 90% tungsten) is more effective than other materials.

Still another use is for high rotational inertia . . . such applications as gyroscopic rotors and torsional vibration dampeners.

The piece shown above left indicates the excellent machinability of Kennertium. It also has high malleability (10% elongation) at high tensile strength (115,000 psi). For more information, send for Kennertium Properties Booklet. KENNAMETAL, INC., Department PE, Latrobe, Pennsylvania.

*Trademark 34227

INDUSTRY AND KENNAMETAL ...Partners in Progress


# FOR YOUR INFORMATION (personal)

### Kidding the Space Age

Two little booklets whose only aim is an engineered chuckle are being offered by Audio Devices Inc. They're cartoon collections (samples below); about 24 pages each; one published last year, the other brand-new. The title: "Studies in Space Age Psychology." Copies are free of charge from AD, 444 Madison Ave., New York 22.

### Sailor's Dozen

Eleven new products to tempt the sailing gentry are being introduced this spring by DuPont. Ten are cleaning and engine-care materials; the eleventh, a new urethane caulking compound.

In the group are three new sponges (there are already four in DuPont's "7 Seas" line), an engine cleaner, a boat-bottom cleaner, a fiberglass cleaner, and a collection of waxes and polishes.

The caulking compound, DuPont says, will retain its elasticity for six years at least, and stands temperatures from minus 75 to plus 150 F. This soft composition can be applied by gun or knife, dries in 24 hr and self-cures in about a week.

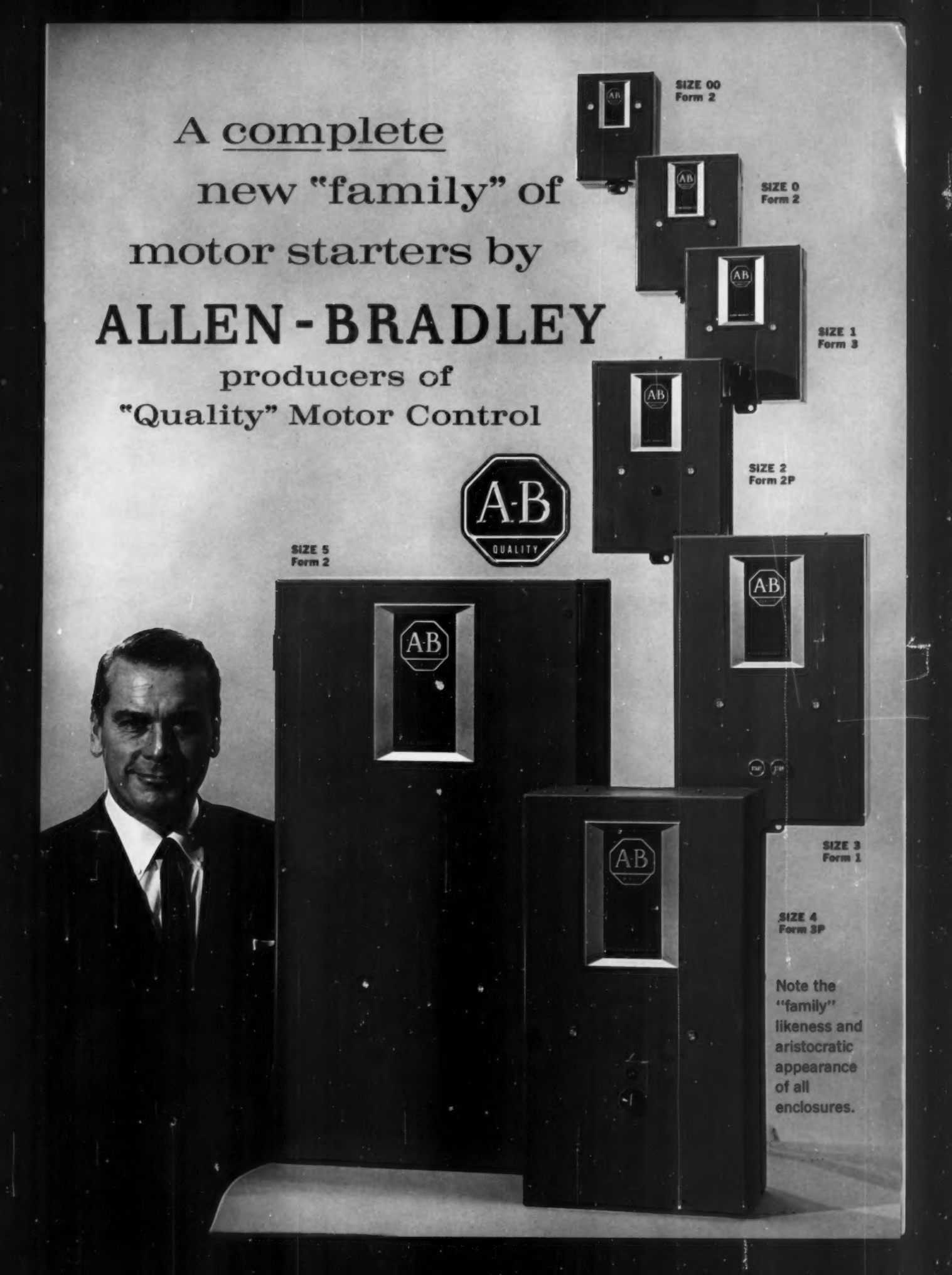
They'll all be in national distribution at prices from $1 to $2 for the cleaners and king-size sponges; $45/gal. for the caulking composition.

### Lots of Lights

If one of those miniature lamps on your car blows, don't worry—just be sure you have these little kits on hand. One 6-v and one 12-v set includes lamps that "meet the safety lighting requirements of practically all cars." They might come in handy in the lab, too—they're among the most popular of the miniature lamps used for instrument and pilot lights (see *PE*—July 18 '60, p 57). The kit is by Westinghouse; the photo from Eastman Chemical Products. —ARG

# A complete new "family" of motor starters by ALLEN-BRADLEY

producers of
"Quality" Motor Control



# Greatest advance in motor

***PLUS VALUES OF THESE NEW STARTERS***

- smaller size
- greater interrupting capacity
- even more millions of trouble free operations
- more wiring room
- elegant styling
- A-B "quality" throughout

**Thirty years of experience have gone into the design of this new Allen-Bradley line of motor starters.** While retaining the principle of the simple solenoid design—with only ONE moving part—everything about these Bulletin 709 starters is **new**.

They're small—especially in the higher ratings. Yet, size for size, all tests have proved that they will outlast any starter now on the market —many times.

The **new**, patented, high-efficiency magnet—remarkably powerful for its weight and size—is cushioned to reduce shock and wear. The **new** coil is encapsulated for mechanical protection, and cannot be damaged by any corrosive atmosphere in which it may be used. The **new** precision hot molded arc hood confines the arc and increases the interrupting capacity.

## ALLEN-BRADLEY

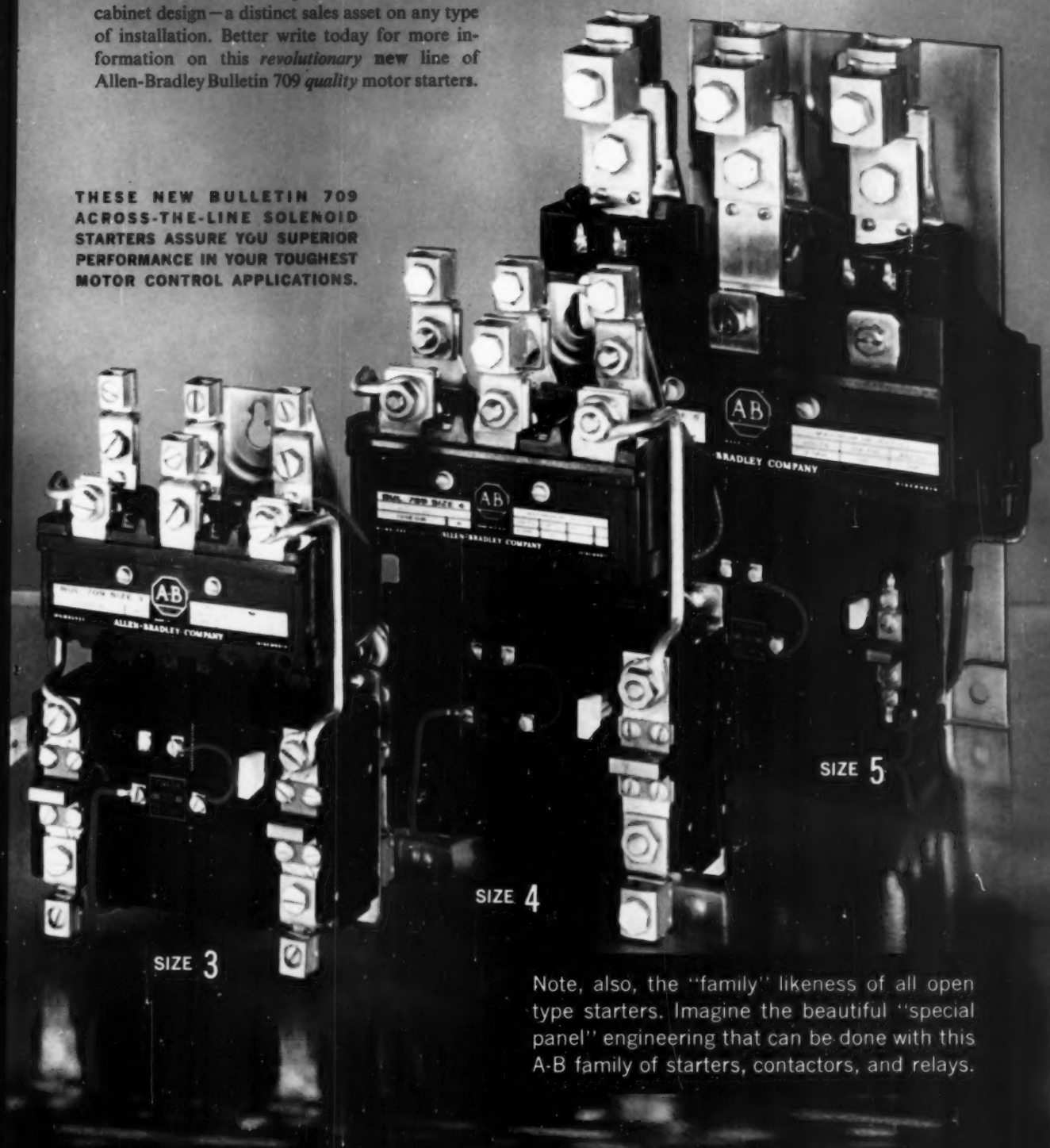
Bulletin 709
Quality Motor Control

# control...in 30 years!

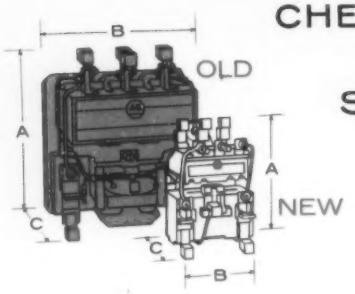
**New** weld-resistant, cadmium oxide silver contacts close and seat firmly, eliminating the sliding motion that causes wear. The overload relays are also **new** and are not only completely *trip-free* but also *tamperproof*. Of course, they were designed to use the **old** Bulletin 709 heating elements you have in stock.

Brooks Stevens is responsible for the smart cabinet design—a distinct sales asset on any type of installation. Better write today for more information on this *revolutionary* **new** line of Allen-Bradley Bulletin 709 *quality* motor starters.

**THESE NEW BULLETIN 709 ACROSS-THE-LINE SOLENOID STARTERS ASSURE YOU SUPERIOR PERFORMANCE IN YOUR TOUGHEST MOTOR CONTROL APPLICATIONS.**

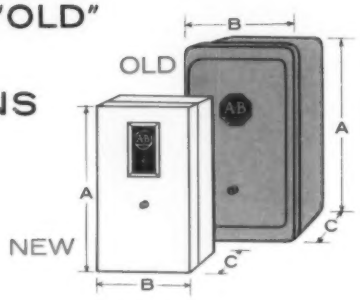



Note, also, the "family" likeness of all open type starters. Imagine the beautiful "special panel" engineering that can be done with this A-B family of starters, contactors, and relays.



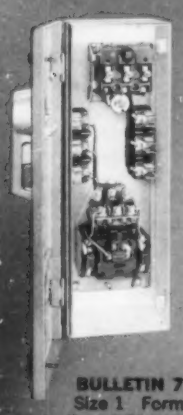

# CHECK THE "NEW" WITH THE "OLD" BULLETIN 709 SPACE-SAVING DIMENSIONS

The wiring room in the new enclosure will delight the electrician.

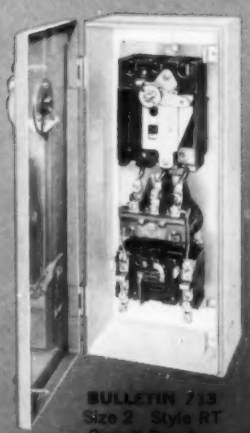



| Starter Size | TOTAL OVER-ALL DIMENSIONS — OPEN TYPE STARTERS | | | | | | NEMA 1 ENCLOSURES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NEW | | | OLD | | | NEW | | | OLD | | |
| | Height A | Width B | Depth C | Height A | Width B | Depth C | Height A | Width B | Depth C | Height A | Width B | Depth C |
| 00 | 3 5/8 | 3 7/8 | 3 9/16 | — | — | — | 7 5/8 | 4 7/8 | 4 1/4 | — | — | — |
| 0 | 5 7/8 | 4 1/16 | 3 1 1/16 | 5 5/8 | 4 3/4 | 3 1/4 | 9 1/8 | 6 5/16 | 4 3/8 | 7 7/8 | 5 5/8 | 4 1/4 |
| 1 | 6 5/8 | 4 1/2 | 3 1 1/16 | 5 7/8 | 5 | 3 1/4 | 10 | 6 13/16 | 4 3/8 | 8 13/16 | 6 3/8 | 4 1/4 |
| 2 | 7 3/4 | 4 5/8 | 3 1 1/16 | 10 1/16 | 5 3/4 | 4 7/32 | 12 | 7 5/8 | 4 3/8 | 14 1/2 | 9 | 5 7/16 |
| 3 | 10 1/4 | 6 1/4 | 5 7/16 | 12 5/8 | 7 1/4 | 5 7/16 | 16 5/8 | 10 3/8 | 7 | 19 1/2 | 11 3/8 | 6 1 1/16 |
| 4 | 11 7/16 | 7 5/16 | 6 1/4 | 16 1/4 | 12 3/4 | 6 13/16 | 22 | 11 5/8 | 8 | 26 9/16 | 14 3/16 | 7 1 1/16 |
| 5 | 14 13/16 | 9 | 6 1/2 | 20 | 16 1/8 | 8 3/4 | 32 3/16 | 17 3/16 | 9 7/8 | 41 1/2 | 19 9/16 | 13 9/16 |

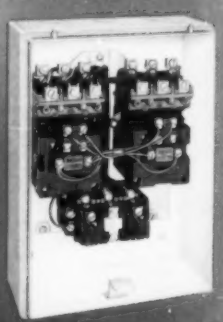
## Also...other across-the-line starters in the NEW A-B design!



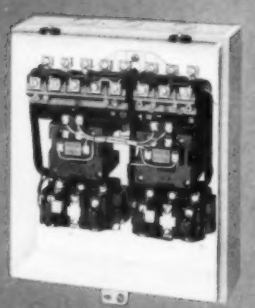
BULLETIN 712
Size 1 Form 2F
Fused Disconnect



BULLETIN 713
Size 2 Style RT
Circuit Breaker



BULLETIN 705
Size 1 Style RT
With Overload Relays



BULLETIN 715
Size 1 Two Speed
Consequent Pole

# ALLEN-BRADLEY

Member of NEMA

*Quality Motor Control*

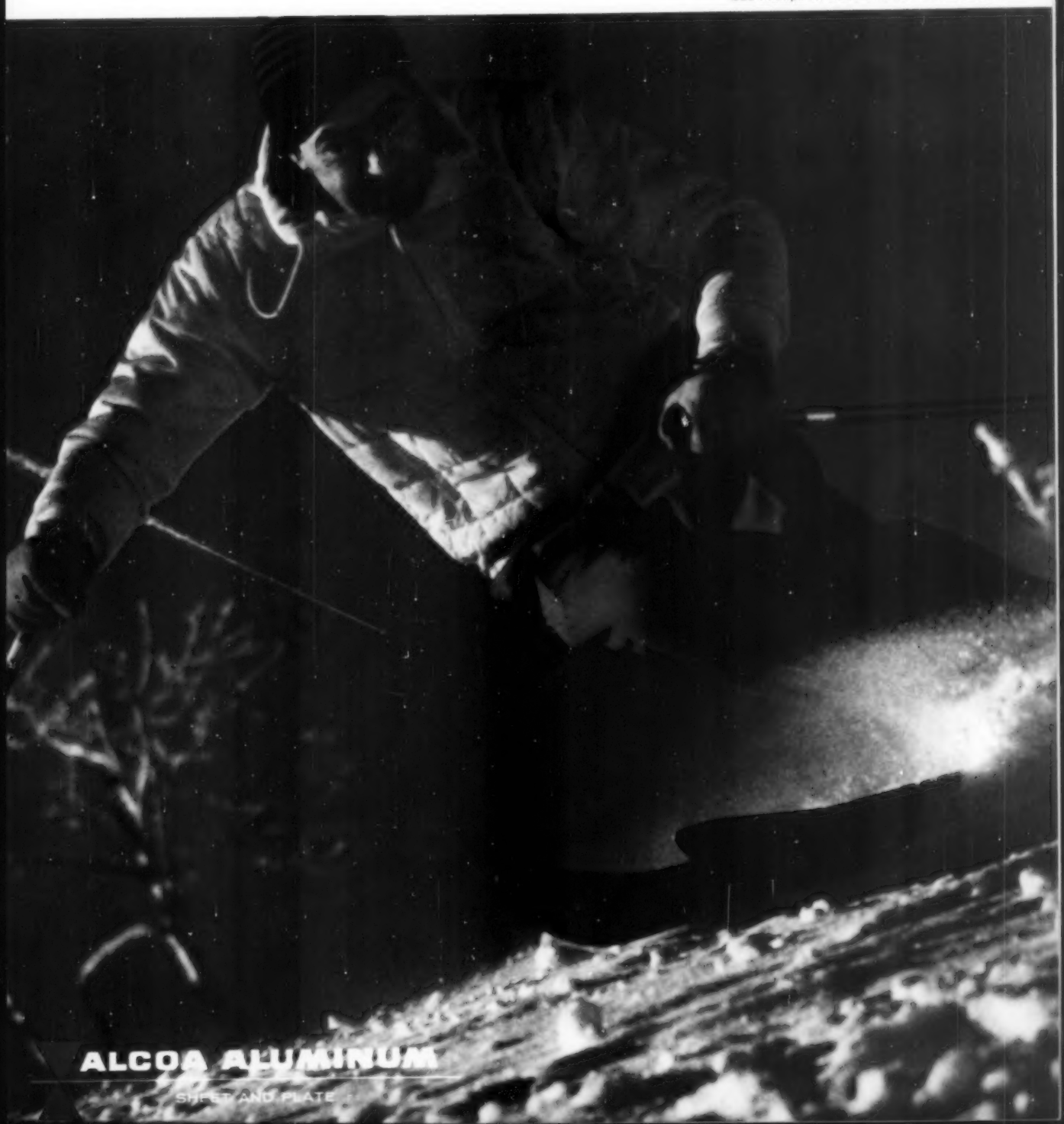
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wisconsin

A-B QUALITY

9-61-RM

*When a six-pound aluminum ski takes a 10-G load . . .*

Bud Phillips on Head Skis at Mad River Glen



*When a 6-pound ski takes a 10-G load . . .* # *that's Alcoa Total Ability at work!*

Talk about strength-weight problems! When a husky skier whistles into a tight turn, he puts a surge load of 10-G's or more on a single leg. To stand loads like this, a ski must be strong enough at the footpad to support a ton. At the same time, the ski can't weigh more than five or six pounds.

Head Ski Company was the first ski manufacturer to exploit the gifts of the strongest aluminum alloy made—an Alcoa development. Springy, lively aluminum alloy and Head's mastery of design make possible a sandwich construction which places the elastic, strength-carrying material at the surface, as far as possible from the neutral axis. Lightweight core material in between carries shear loads. Head skis won't twist in action like a wood ski, won't warp, dry out, deteriorate, lose camber or life or resilience or strength.

No one knows more about aluminum sheet and plate—nor makes more alloys, tempers, finishes, widths, thicknesses (even *tapered*)—than Alcoa. *Alcoa Total Ability* includes working with your people from the design stage to the finished product, with significant contributions all along the way. Let us prove it. Simply contact your nearest Alcoa sales office, or write Aluminum Company of America, 857-C, Alcoa Building, Pittsburgh 19, Pa.

**ALCOA ALUMINUM**

SHEET AND PLATE

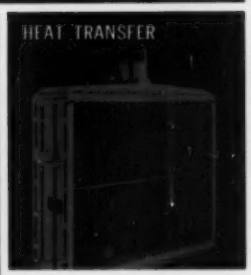
ALCOA TOTAL ABILITY GIVES YOU SHEET AND PLATE THAT'S UNSURPASSED FOR

NONTOXIC PROPERTIES

MACHINABILITY

REFLECTIVITY

WELDABILITY



HEAT TRANSFER

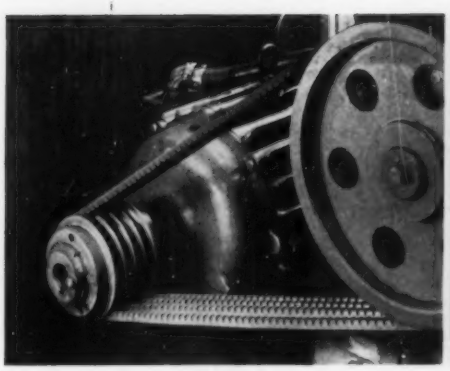
CORROSION RESISTANCE

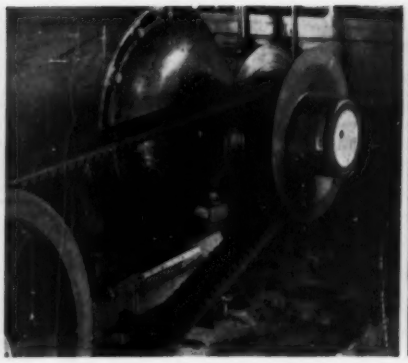
FORMABILITY

FINISH AND TEXTURE

STRENGTH-WEIGHT RATIO

NONSPARKING PROPERTIES





# Wood's specialization provides the right drive to solve your belted transmission problems . . .

. . . particularly if your problems involve horsepower, high, low or variable speeds, drive efficiency, space, economy or availability.

This is because Wood's people are specialists in the production, selection and application of *all* basic types of belted drives.

We are able to provide the *right* drive for a specific application because we manufacture all of the basic types. So, drive problems can be solved by Wood's fast and economically.

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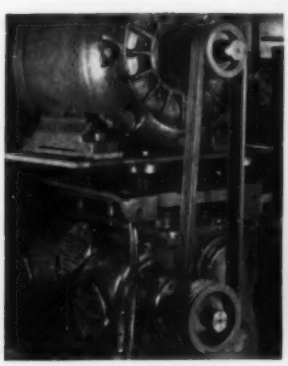

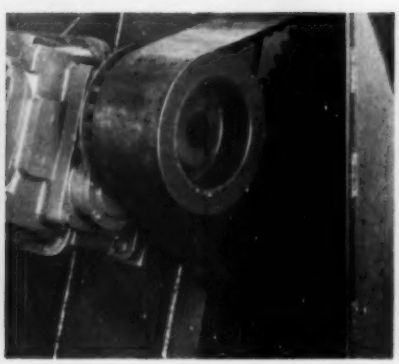

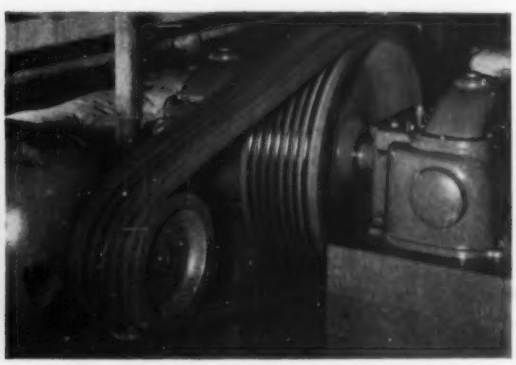

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PRODUCT ENGINEERING HORIZONS

March 27, 1961

# Who makes YOUR decisions?

In approaching an engineering problem, you marshal all the available facts, make any necessary assumptions, then test to see how good your assumptions are.

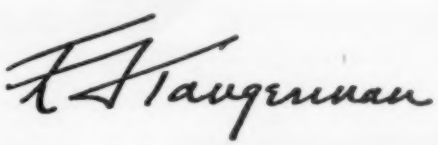
This procedure is excellent for a physical problem and usually leads to a sound—or at least defensible—decision. Following this line of attack, the man with greatest experience or knowledge should get the best result, because he has more background on which to base his decision. This takes us increasingly to the specialist in every form of technology and science, to the man who presumably has more facts available and can make more logical assumptions. We find the specialist in medicine, in law, in government, in foreign affairs, in economics. Indeed, it is more and more common to hear that our modern world is so complex that only specialists can run it.

This just isn't so. The expert serves his purpose in providing facts, but he may be entirely wrong as the man to make the decision. He inevitably will be influenced by his specialized knowledge, limited by it, so to speak. It's obvious enough in medicine, where the heart specialist lays all our ills to the heart, the orthopedist to faulty posture, and so on. It can happen in engineering, too, when the materials specialist, or the process specialist, or the parts specialist has his say. The great problem of the specialist is that he may not be able to see the forest for the trees.

Throughout recorded history, the men who made the vital decisions were not specialists. Alexander and Caesar were great conquerors, but their political backgrounds were frequently more important than their military ones. Lee, Grant, Clausewitz, Bismarck, Ney—here were great military tacticians who had little political competence, and some of their military decisions are open to question in the light of re-examination of the facts.

Basically, the technical components of any decision are relatively few. The decider often cannot judge soundly without some technical competence. But to leap from this to the conclusion that only a trained man can decide a problem is to make a basic mistake. The trained man may have a "trained incapacity" to make a practical decision, an inability to discard or disregard some facts unessential to the present solution.

Decision-making is still, as it always was, intuitive. This is abhorrent to the trained mind, which glorifies committee decisions based on visible, marshaled evidence and suspects the private, mysterious and invisible process of judgment in a gifted individual. We democratize decision-making—the majority rules—and then we wonder why the decisions are bad.



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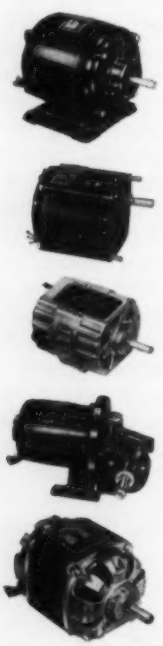

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PRODUCT ENGINEERING

# WHICH INSTRUMENT MOTOR for the JOB?

**ROBERT W MATTHEWS,** *chief engineer*
*Holtzer-Cabot Motor Div*
*National Pneumatic Co Inc*

**When choosing a fractional or subfractional motor for instrument use, these factors will determine the type of motor you need—starting torque, response time, low-slip speed, exact speed, and adjustable speed range.**

For instance, if the application demands exact speed, then only a synchronous motor will do. If one or more of the other factors are critical, a glance at the bar graph below will quickly eliminate inappropriate motor types. Then take a closer look by turning to the performance table on page 44 where all types are compared in detail. Now you are ready to make a final choice, or to ask the right questions of your supplier.

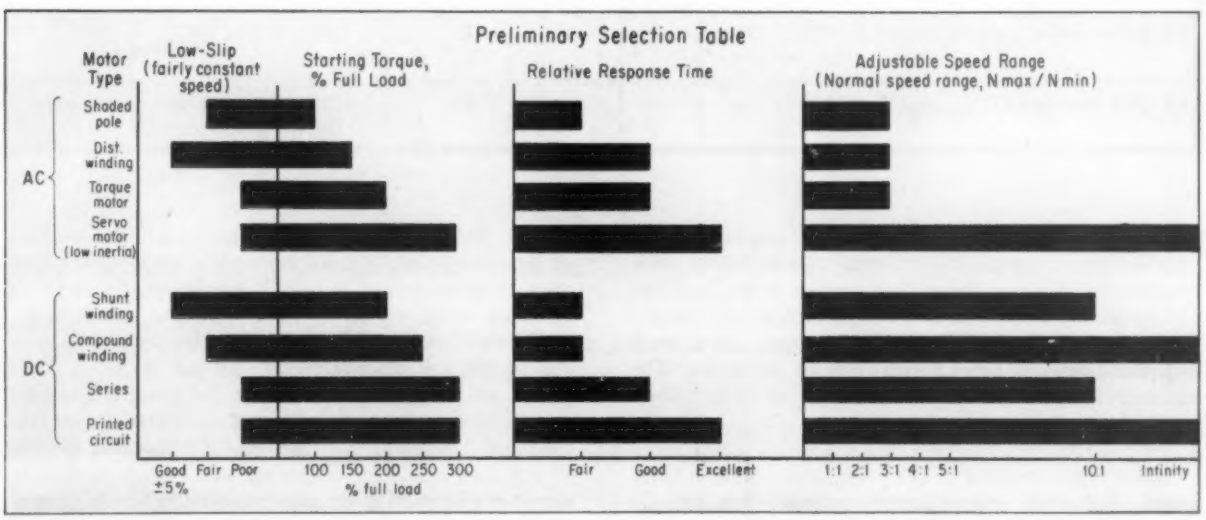
**WHAT IS AN INSTRUMENT MOTOR?**

**Because there is no standard definition, for purposes of this article we will define an instrument motor as a small precision motor having a horsepower range from 1/2000 to 1/20, and used for capstans, turntables, torque motors, chart and pen drives, variable-speed drives, servo applications, fans and blowers, and the like.**

### Preliminary selection

When only one of the factors in the bar graph is critical, selection of a motor type is relatively simple. For example, if you need high starting torque, the servomotor stands out, along with several dc motors. You can decide right away whether you prefer ac or dc, depending on what's available, or turn to the performance table and compare other criteria such as efficiency, braking, etc.

continued, next page






REPRINTED—Circle 596, inside back cover

**PERFORMANCE**

| Type of Motor in order of increasing cost within each group | Power Supply | | | | % Change in Speed from No Load to Full Load | Maximum Hp | Starting Torque, % of full load | Response Time |
|---|---|---|---|---|---|---|---|---|
| | Voltage | | Phase | | | | | |
| | Std. | Avail. | Std. | Avail. | | | | |
| 1 Induction Shaded Pole | 115 | — | 1 | — | 6 | 1/20 | 100 | Fair |
| 2 Induction Distributed Windings | 115 | 230 | 1 | 2 & 3 | 4 | 1/20 | 150 | Good |
| 3 Induction Torque Motor | 115 | 230 | 1 | 2 & 3 | — | 1/20 | 200 | Good |
| 4 Induction Servomotor (low inertia) | 115 | 230 | 1 | 2 | 40 | 1/20 | 300 | Excellent |
| | | | | | | | | |
| 5 Permanent Magnet Synchronous (clock type) | 115 | 230 | 1 | — | None | 1/2000 | 100 | ——— |
| 6 Hysteresis Synchronous Shaded Pole | 115 | 230 | 1 | — | None | 1/50 | 100 | ——— |
| 7 Reluctance Synchronous | 115 | 230 | 1 | 2 & 3 | None | 1/20 | 150 | ——— |
| 8 Hysteresis Synchronous | 115 | 230 | 1 | 2 & 3 | None | 1/20 | 100 | ——— |
| 9 Polarized Synchronous | 115 | 230 | 1 | 2 & 3 | None | 1/20 | 100 | ——— |
| 10 Inductor Synchronous (stepping motor) | 115 | 230 | 1 | — | None | 1/50 | 100 | ——— |
| | | | | | | | | |
| 11 Dc Shunt | 115 | 230 | — | — | 10 | 1/20 | 200 | Fair |
| 12 Dc Series | 115 | 230 | — | — | — | 1/20 | 250 | Good |
| 13 Dc Compound | 115 | 230 | — | — | 25 | 1/20 | 300 | Fair |
| 14 Dc Printed Circuit | 115 | — | — | — | 40 | 1/20 | 300 | Excellent |

If two or more factors are critical, choosing a motor may be more complicated, possibly necessitating some compromise. For one thing, high starting torque and low-slip speeds are reciprocals as a function of motor design—you can't have both. The best compromise is either a distributed-winding ac or a shunt-wound dc motor. The performance table will quickly eliminate one or the other.

**The performance table**

Motor types are listed in the performance table in three groups: induction motors, synchronous motors, and dc motors. Within each group, the motors are listed in order of increasing cost, but no attempt is made to compare costs between groups, although synchronous motors are generally more expensive than induction motors. Dc-motor costs vary widely, depending on requirements of quality, life, and other factors.

Two unique types are included in the table: the stepping motor and the printed-circuit motor. The first is a specially constructed inductor-type synchronous motor that operates at very slow speed on 60 cycles, and can be stepped by means of a dc pulse to the proper winding. The dc printed-

**OF INSTRUMENT MOTORS**

| Theoretical Acceleration at Stall | Dynamic Braking | Adjustable Speed Range | Reversibility | | Efficiency | Typical Applications |
|---|---|---|---|---|---|---|
| | | | From Rest | While Running | | |
| Low | Dc in Winding | 35–100% at Full Load | No | No | Low | Fans, Blowers, Power |
| Medium | Dc in Winding | 35–100% at Full Load | Yes | Yes | Medium | Fans, Power, Dictagraphs |
| Medium | Capacitor Shorting | 35–100% at Full Load | Yes | Yes | Low | Pen Drives, Valve Control |
| High | Capacitor Shorting | 0–100% at Full Load | Yes | Yes | Low | Pen Drives |
| | | | | | | |
| Low | ——— | ——— | No | No | Low | Chart Drives |
| Low | ——— | ——— | No | No | Low | Chart Drives |
| Low | ——— | ——— | Yes | Small: Yes Large: No | Low | Chart Drives |
| Low | ——— | ——— | Yes | Small: Yes Large: No | Medium | Capstans, Turntables |
| Low | ——— | ——— | Yes | Small: Yes Large: No | High | Mechanical Rectifiers, Choppers |
| Medium | ——— | ——— | Yes | Small: Yes Large: No | Low | Low-speed Synchronous, Servo Applications |
| | | | | | | |
| Low | Armature Shorting | 10: 1 | Yes | Small: Yes Large: No | High | Variable-speed Drive |
| Medium | Armature Shorting | 0–100% at Full Load | Yes | Small: Yes Large: No | High | Torque Motors |
| Low | Armature Shorting | 10: 1 | Yes | Small: Yes Large: No | High | Variable-speed Drives |
| High | Armature Shorting | 0–100% at Full Load | Yes | Yes | High | Servo Applications |

circuit motor is a patented device with a printed-circuit rotor. Practically any type listed in the table could be made with a printed-circuit rotor, but the type now on the market is a permanent-magnet field motor. Major advantage is that it has extremely low rotor inertia.

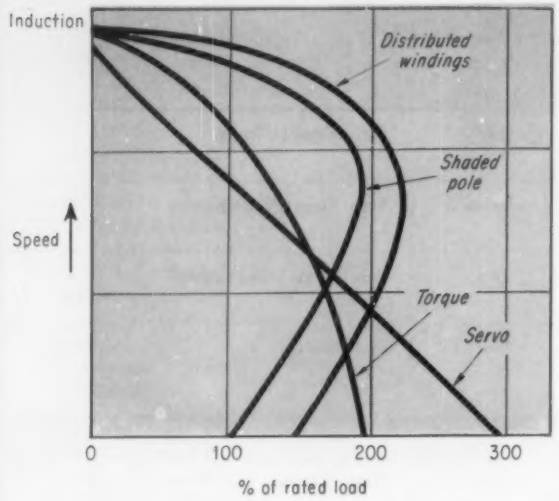
**Speed of motor.** For an ac motor, speed is determined by rpm = 120 $f/p$, where $f$ is input frequency and $p$ is number of poles. The number of poles is limited to eight because of practical construction limitations. The 60-cycle motors are therefore available in 2-, 4-, 6-, and 8-pole versions, giving speeds of 3600, 1800, 1200, and 900 rpm; 400-cycle motors have top speed (2-pole) of about 24,000.

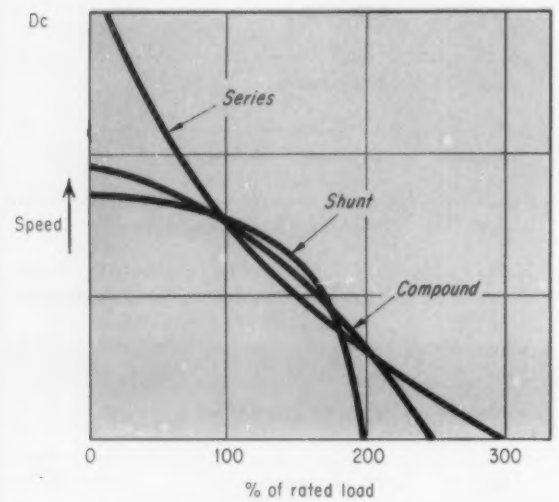
The dc series-wound motors offer speeds from 5000 to 15,000 rpm, whereas other types of dc motors have a normal range of 1000 to 5000 rpm.

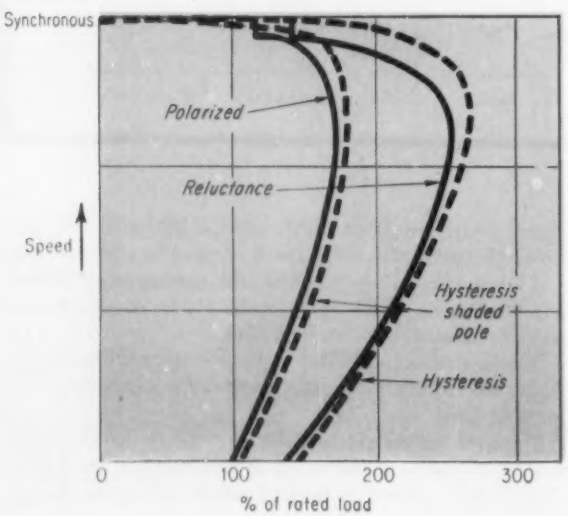
The best that induction or dc motors can offer in constant speed is ±5%; for exact speed the synchronous motor must be used.

Standard motors are available with performance characteristics as shown in the table. If your application requirements won't permit using a standard unit, consult your

**OVERLOAD PERFORMANCE for the three groups of instrument motors**




supplier for advice on a special motor. Following is a discussion of each of the performance characteristics listed in the table.

**Voltage supply**—although single-phase, 115-v, 60-cycle ac is always available, your application may require polyphase ac, or 400-cycle ac, or dc. Each of these has its advantages. For example, polyphase 60-cycle motors provide easier starting; 400-cycle ac permits motors to be smaller, lighter, faster for same hp rating; and dc provides precise speed control. A disadvantage shared by all three is that the standard 60-cycle ac must be changed, and this adds to cost.

Choosing among the synchronous motors depends largely on cost, power needed, and other factors such as reversibility, torque characteristics and rotor positioning. When uniform rotational torque is required or the load has high inertia, a hysteresis synchronous motor may be needed. It uses cobalt rings (cylinders) and requires special manufacturing and heat-treating techniques. When the rotor shaft must assume the same relative position with respect to the input phase, only a polarized synchronous motor (the most expensive) will do. For low synchronous speeds (down around 75 rpm), the inductor motor can be used as servomotor without a gearhead.

**Maximum horsepower**—although instrument motors as defined in this article have a maximum of 1/20 hp, most of the motors listed can exceed this level. All the induction motors have a maximum of $\frac{3}{4}$ hp, except the shaded pole which goes to $\frac{1}{6}$. The hysteresis and reluctance synchronous types go to $\frac{1}{8}$ and $\frac{3}{4}$ hp respectively. The dc's all go to $\frac{3}{4}$ hp.

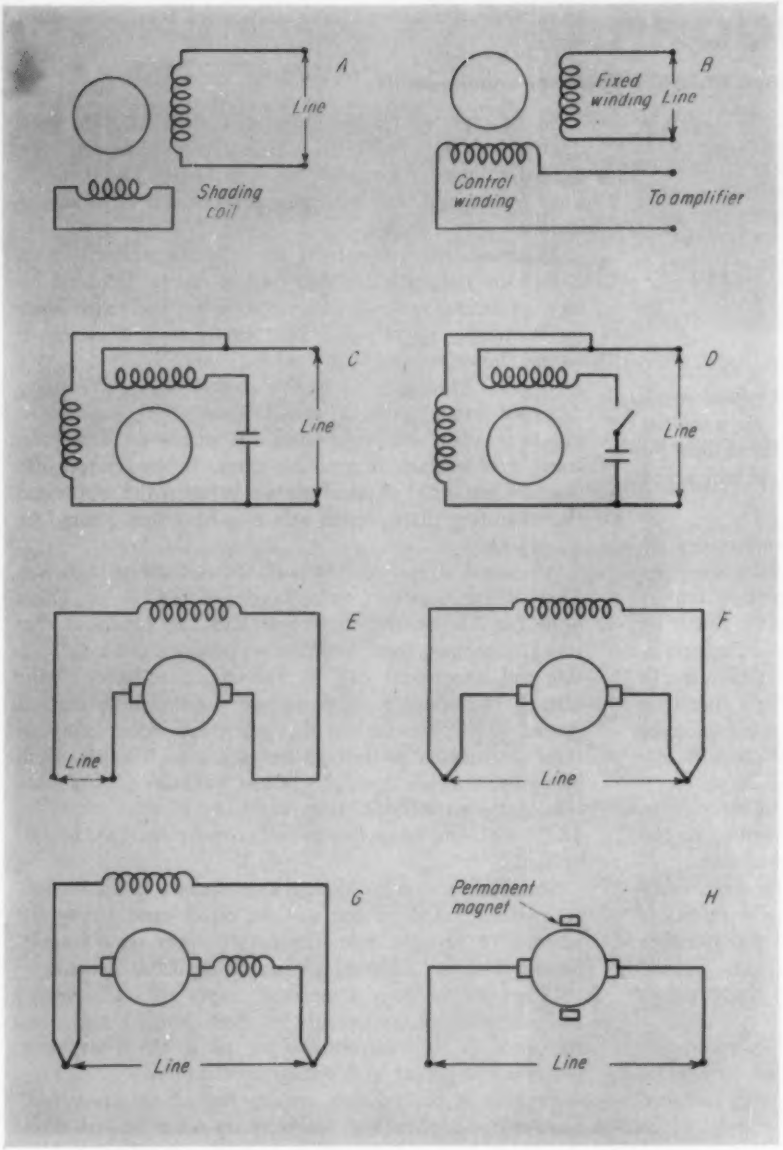
**Torque requirements**—as shown graphically in the preliminary-selection table, starting-torque capabilities vary among motor types. When loads require higher than normal starting torque, or when the motor type you must use (because of other factors) will not provide enough starting torque, try a larger motor if space permits.

Pull-up torque is important where the load builds up as the motor starts to rotate. An induction motor will carry more than 175% of rated load if the load is applied after the motor is up to speed, but it will not start and pull this load up to speed.

Breakdown torque is important where the load is intermittent and where it is desirable to maintain momentary overloads without completely stalling the motor. Torque and servomotors are designed to have breakdown and stall torques at the same point—to give the highest possible starting torque for the least amount of input power. Performance of the various motor types when subjected to overload is shown in curves at left.

**Response time**—also known as time constant, response time is a theoretical figure of merit based on rotor inertia, stall torque, and no-load speed, which gives an indication of motor ability to come up to speed. This is extremely important with servomotors, which must re-position instantly, but is not critical for most other applications.

**Theoretical acceleration at stall**—this is another figure of merit useful in comparing various motor types. It is the ratio of stall torque to rotor inertia and indicates the motor's ability to follow input signal changes.




**WIRING DIAGRAMS** of basic motor types. Numbers refer to order in performance table.
**A**—Induction shaded pole: 1, 6.
**B**—Induction servo: 4.
**C**—Induction permanent-split capacitor: 2, 3, 5, 7, 8, 9, 10.
**D**—Induction capacitor start: 2, 3, 5, 7, 8, 9, 10.
**E**—Dc series: 12.
**F**—Dc shunt, 11.
**G**—Dc compound, 13.
**H**—Dc permanent-magnet field, 14.

**Dynamic braking** is ability of a motor to come to an abrupt stop when properly energized. A dc motor will stop quickly when its armature is shorted and the field is energized. Depending on size, it may be necessary to place some resistance in series with the armature to keep the shorting current to a reasonable level. Single-phase ac motors will stop when energized by sufficient direct current. Some permanent-split capacitor motors will stop abruptly when both windings are supplied from the same line (capacitor-shorted).

A motor used for valve control or any type of critical positioning must be capable of dynamic braking. Many small motors can be dynamically braked with simple switching because the input watts to the motor are the same or less than rated input. Larger motors require more intricate switching to remove the motor from the line immediately after stopping. Various starting and stopping cycles may require special motors because of temperature-rise limitations of the insulation.

**Adjustable speed range**—for precise speed control over a wide range, a dc shunt motor is unexcelled. A rheostat in series with the shunt field permits about a 2-to-1 change, while a rheostat in series with the armature will allow 10 to 1. Series armature resistance will cause more fluctuation in speed with change in load or line voltage than when variable voltage is applied to the armature. Small dc motors have found increasing applications because of availability of static rectifiers and variable-voltage transformers. The speed of dc series motors can be controlled by varying input voltage, but speed varies widely with changes in load. With small permanent-split capacitor motors, satisfactory speed control over the range from rated to 35% of rated speed can be had by using rheostats in series or parallel with capacitor windings. The load

**REVERSIBLE? OR REVERSING?**

**The ASA defines two types of reversibility. A motor that can be reversed while running is called a reversing motor. But one that can be reversed only if allowed to come to a stop first is called a reversible motor. Though this nomenclature is not universally used, it provides a useful distinction.**

must be fairly constant and exact speed cannot be critical. Servomotors normally have line voltage in the fixed winding. Speed and direction are determined by amplifier output to the control winding. Shaded pole motors for blower applications use a series resistor to obtain speed control.

**Reversibility**—direction of rotation of dc motors can be changed by reversing either armature or field windings with respect to each other. Permanent-magnet dc motors can be reversed by changing the line polarity. Small dc motors can be reversed while running; special circuitry is required for larger sizes. All shunt and series motors can be reversed if first allowed to come to a stop. Small dc motors, however, are frequently designed for maximum brush life and commutation in a particular direction of rotation. This is why reversibility must be specified.

Shaded pole motors are normally made for rotation in one direction only. Reversibility can be achieved by special design and circuitry but at substantially higher cost.

Single-phase ac motors that use a starting mechanism (relay or centrifugal switch) are not normally reversible while running. They can be connected to run in either direction and will reverse if allowed to stop. Special switching mechanisms are available to permit these motors to reverse while running.

Small permanent-split capacitor motors (a 2-phase motor with a capacitor in one phase, and designed to operate from a single-phase source) can be designed with balanced windings to give reversibility while running.

Polyphase motors can always be reversed if allowed to stop, and most small sizes are reversible while running or can be plugged to a stop. Size of motor and frequency of reversing determine whether it is possible to use a standard design.

**Efficiency**—because the total power consumed by instrument motors is small, efficiency is seldom important. Low efficiency means, however, that considerable heat must be dissipated. This is sometimes a problem with a 2-phase servomotor whose reference winding is continuously energized while the motor rotates only when there is an error signal.

### Other requirements

So far, only motor operating characteristics have been discussed. Various other requirements should also be considered. Again, these may be interrelated, both within their own group and with the performance requirement factors.

Minimum size and weight are generally desirable even if they are not critical. Most motors can be provided for face- or base-mounting, horizontal or vertical, with shaft up or down. These conditions should not be varied in service, however, unless the motor is specifically designed for such. Mounting is usually accomplished by using extended-through bolts on smaller sizes, while base mounting is standard on larger sizes. Resilient mounting on larger sizes is often an available extra. If temperature rise is a problem, good physical contact between the motor and the mounting plate, which acts as a heat sink, should be maintained.

Abnormal air pressure is normally not a consideration. Temperature, however, is frequently critical. It can affect both the life of the insulation and the bearings. For standard motors, total ambient temperature (ambient outside the instrument case + rise above ambient in the case + rise above ambient in the windings) should not exceed 105 C. Insulations that will stand higher temperatures are available as are high-temperature lubricants. Both generally involve special motors, however. Standard lubricants permit operating ambients from −20 C to 40 C. Extreme temperatures may require auxiliary heaters or fans.

Standard motors are designed to operate in air or noncorrosive atmosphere—but not for direct exposure to the weather or to meet humidity or salt spray requirements. Semiprotective enclosures are usually available as extras.

Quiet operation is sometimes important. Dc motors are inherently noisy because of their brushes and commutators, so are unacceptable for use in office machines, hospital equipment and similar applications.

Because of basic design, smaller motors are impedance-protected, i.e. they will not burn up when stalled across the line. Larger sizes require special protection such as fuses, circuit breakers and thermostatic devices.

Life expectancy of motors is extremely difficult to predict. Conservatively rated, properly maintained (lubricated) motors will operate for years. Most manufacturers guarantee for one year only, mainly because bearing manufacturers cannot guarantee their component for longer periods.

**For REPRINT of above article, just check 596 on one of the Reader Service cards bound in this issue.**

**EDITOR'S NOTE: We have published many articles on electric motors in the past few years. See these recent ones for more details on specific aspects of the problem discussed above:**

**How Practical Is 400-Cycle Power—Today?** Mar 6 '61, p 54—Compares 400- and 60-cycle power, especially for use with motors. Predicts that solid-state converters will make 400-cycle power more available.

**Reversal of Electric Motors,** Dec 5 '60, p 84—Points out which motor types are easy to reverse, which are not.

**Design Your Own DC Motors with Printed Circuit Rotors,** Mar 15 '59, p 64—Authors tell how to draw up specifications for a printed-circuit motor.

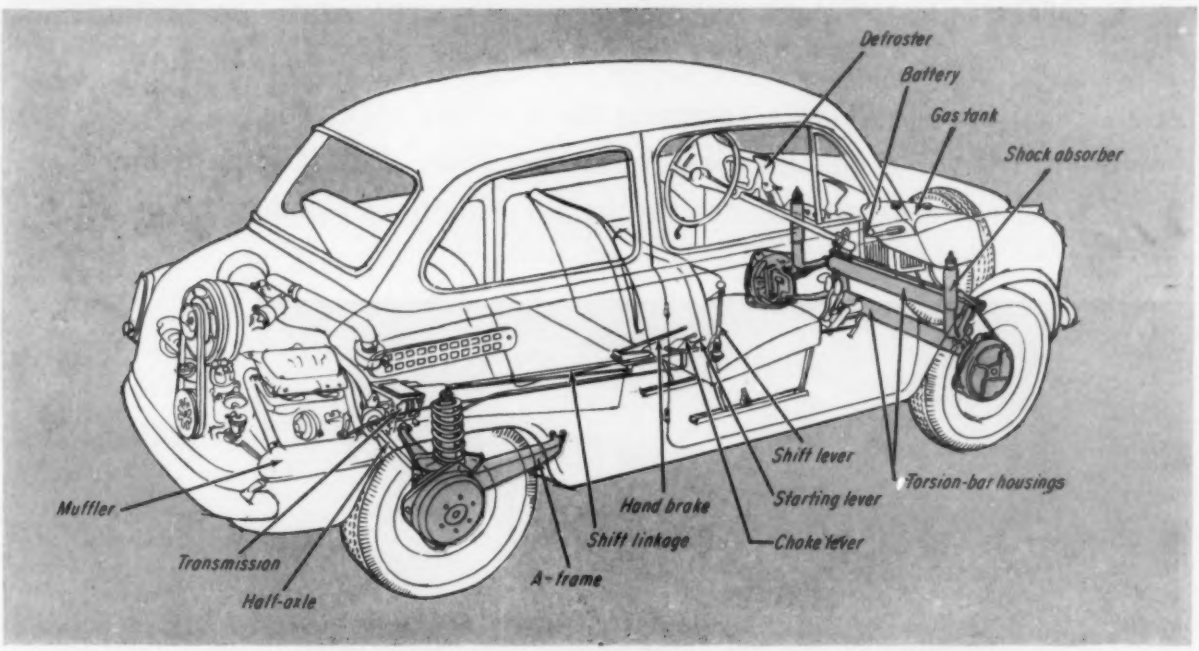
**Which Fhp Motor for the Job?** Jan 19 '59, p 76—Tells how all the types work; charts give applications, costs.

**Let the Load Be Your Guide When Selecting Polyphase Motors,** Aug 18 '58, p 58—Find the correct polyphase motor based on torque, slip, and duty-cycle requirements.

—Frank Hall

# Soviet Compact Has 'Imported' Flavor

**Russians have copied features of several successful European small cars to save engineering time. The main "home-grown" component—the engine—has developed trouble that is delaying mass production.**




**REAR-ENGINE, REAR-WHEEL-DRIVE CAR** has four-wheel independent suspension, hydraulic brakes, and a gas heater. Independent suspension in front uses torsion bars connected to parallel trailing links at each wheel plus tubular shock absorbers. This system is used by Volkswagen and the similarity of the two systems is pronounced.

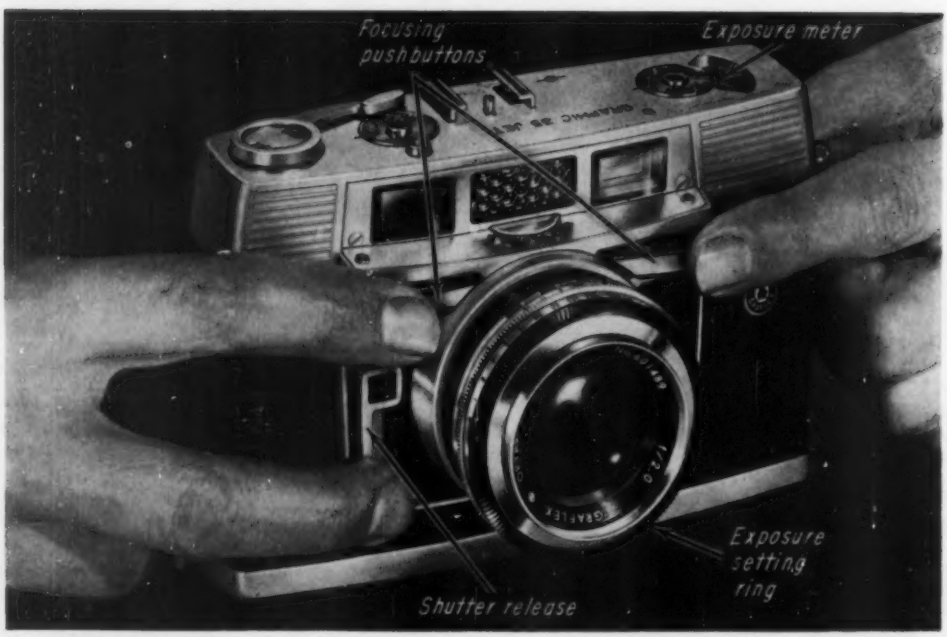
Rear springing is by coils mounted between the body and a box-section A-frame that provides a mount for the wheel bearings. Half-axles which drive rear wheels are pivoted at transmission to allow rear wheels to rise and fall. This system is identical in its essentials and construction details to the Fiat 500 and 600-series light cars. Other points of pronounced similarity to Fiat include the shift linkage plus the location and method of operating the choke and starter. But the most striking point of similarity is the body shape which, except for the extended motor housing at the rear and side vents, imitates the small Fiat closely.

The engine, which is a new unit developed for this car, has proved to be the cause of delay in starting mass production. Primary trouble is overheating of the lubricating oil—a common problem with aircooled engines. Possible solutions suggested by the engine producers are deeper oil pans and improved airflow over the engine. At capacity production levels—not yet reached—94% of all operations will be automated, and each car will represent only 39 man-hours of labor.

**PS . . .** Four-passenger, 2 door sedan weighs 1430 lb; rear-mounted 4-cyl, 4-cycle engine is aircooled. The 746-cc engine is rated 23 hp and has useful capacity of 20 hp. The Soviet magazine *Znaniye I Sila* (Knowledge and Strength) describing the car, complained of noisy gears, overheating of the oil, and excessive gas consumption. The magazine also noted that these deficiencies were being corrected. The Zaporozhets Baby is built in the Kommunar Automobile Plant (ZAZ Zaporozhye, Ukraine, USSR).

# Gas Powers Camera Drive

Carbon dioxide advances the film and cocks the shutter while pushbuttons do the focusing. *Result:* this camera can stay at your eye through a sequence of pictures.



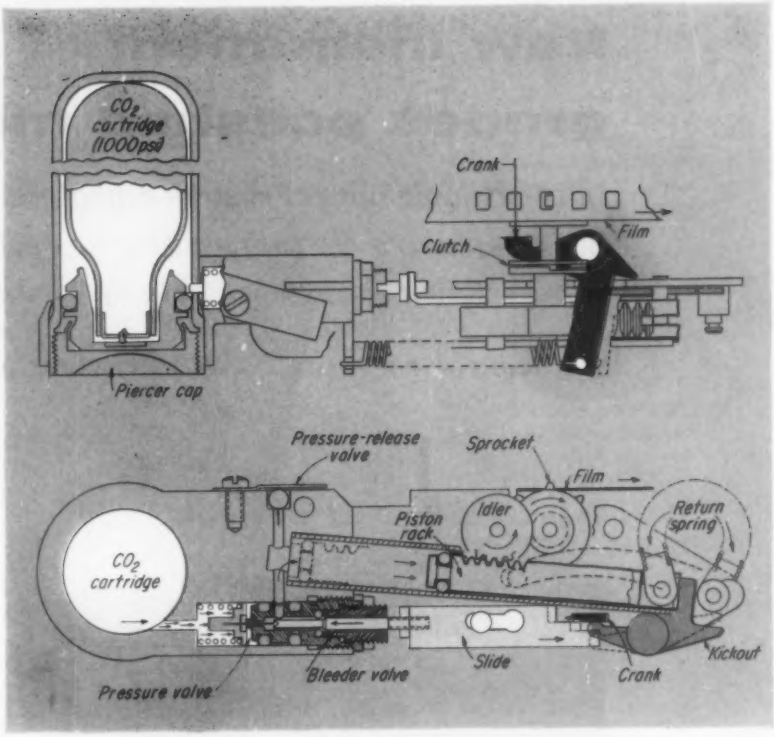

**THE THREE CONTROLS** within fingertip reach simplify picture-taking. Two pushbuttons on its face permit focusing the camera by pressure of the index fingers. The interlocked pushbuttons are connected to the guide over which the film runs. Moving the guide and film rather than the lens simplifies construction by eliminating the usually complex lens drives and the required dust- and light-seals.

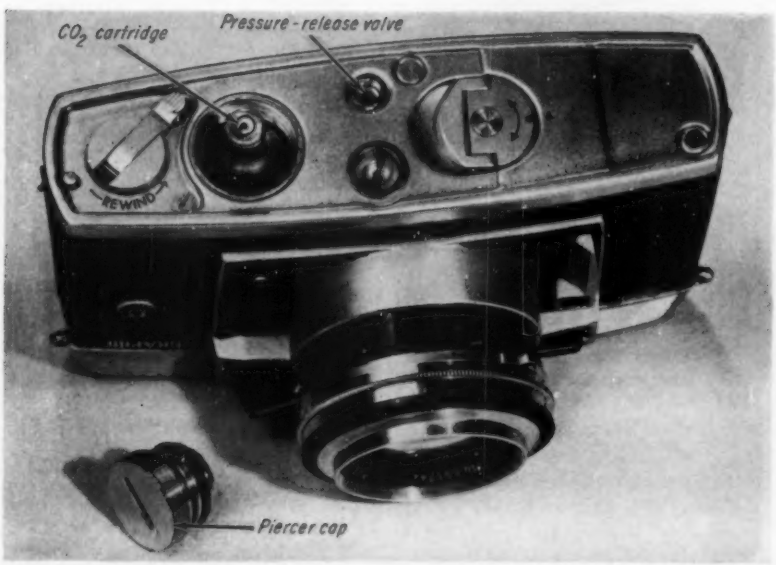
Shutter-release and film-advance operations are controlled by a single lever. First ¼ in. of lever travel trips the shutter; moving the lever an additional ¼ in. actuates the film-advance drive—it moves the film one frame and cocks shutter for the next exposure.

Exposure-setting ring is coupled to the exposure meter to provide correct diaphragm opening and shutter speed. Ring is rotated to align film-speed indicator and exposure-meter needle. Preselected shutter speed remains stationary while diaphragm opening is varied to achieve the correct combination.

**FILM-ADVANCE** and shutter-cocking motions occur after the shutter has been tripped for the previous picture. Final motion of the shutter release pivots crank to engage the release slide which operates gas pressure valve and bleeder valve. As spring pulls the release slide to left, pressure valve is opened and bleeder valve is closed. The escaping $CO_2$ flows through pressure valve and forces piston rack to right. This rack drives the film-advance sprocket and shutter-cocking mechanism through an idler gear and pinion set.

At end of its stroke, piston strikes the kickout which disengages crank and slide. Released slide is driven to the right by gas pressure on the pressure valve and by the valve's return spring. The bleeder valve opens, allowing gas to escape as the piston rack is snapped to left by its return spring.



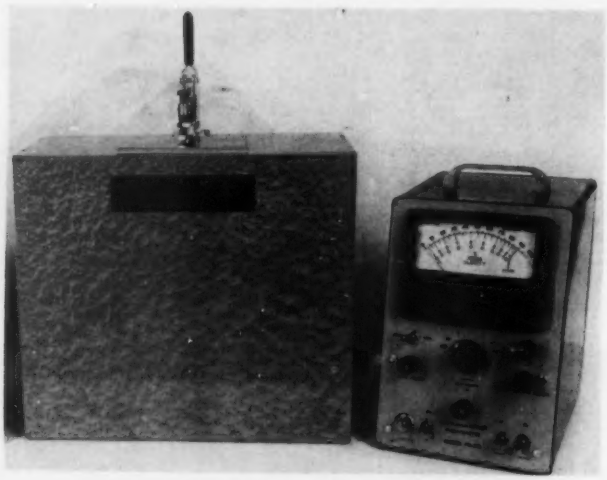

**CARTRIDGE OF $CO_2$** is loaded into base of camera, using a coin to remove and install the piercer cap. Before removing the old cartridge, the pressure-release valve is turned 90° to exhaust remaining gas. When hissing stops, the piercer cap is unscrewed and the old cartridge replaced with a new one. The pressure-release valve is rotated 90° to close it and the piercer cap screwed down onto the cartridge. Once the cartridge is pierced, the cap is locked by pressure of the $CO_2$ and cannot be removed as long as gas pressure remains in the chamber.

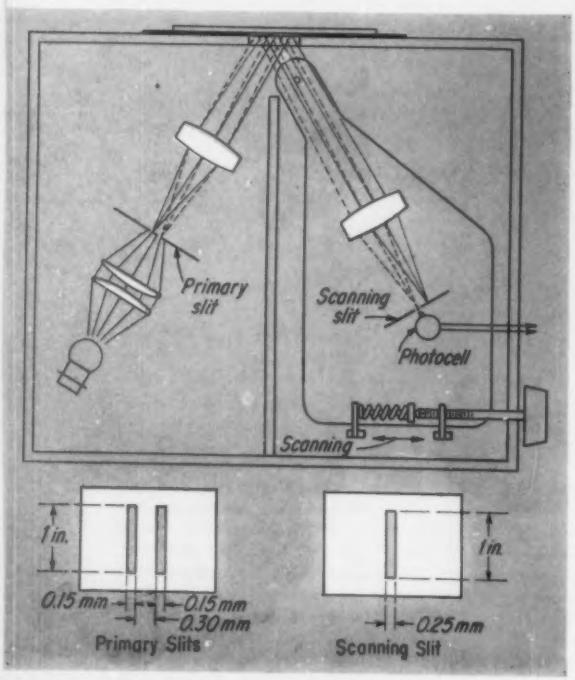
**PS . . . The maker calls it "the international camera" because it's assembled from components produced in three countries. Exposure meter is produced in Germany; the body, optics and shutter come from Japan; finally, the $CO_2$ power unit is produced and the camera is assembled in the US. Each gas cartridge cycles approximately 6 to 8 rolls of 20-exposure film. The 50 mm, f/2.0 lens is coated and color-corrected, shutter is synchronized at all speeds for bulbs and electronic flash. The Graphic 35 Jet is produced by Graflex Inc, Rochester, NY.**

# New instrument grades polished metal surfaces

*In this simple optical system a photocell scans light reflected from the sample and gives quantitative readings that are faster, more reliable than those obtained with subjective, visual methods.*

**W H TINGLE** and **F R POTTER**, *Aluminum Co of America, Pittsburgh*





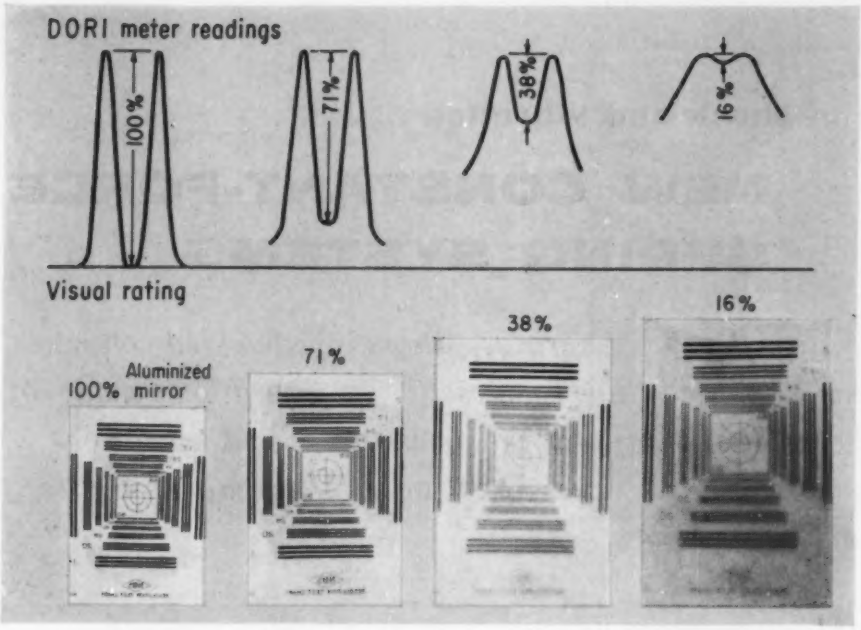

**SAMPLE SERVES AS MIRROR** in simple optical system. Because of this arrangement, quality of final image depends on surface characteristics of sample. Distinctness of image is measured by scanning the two bright lines formed by the second lens. If image is fuzzy, indicating a poorly finished sample, light will be scattered into the area between the two lines.

The quality of a mirror-like finish on metal can be judged by how well it reflects light. A good finish gives a sharp, well-defined reflected image, a poor finish scatters light and gives a fuzzy, low-resolution image. This, in fact, is the basis for tests that have been used for many years. But until recently the tests were limited to the subjective kind that depend on acuity of the inspector's eye and consequently offer poor repeatability. Now a new instrument has been developed to take the guesswork out of reflectivity measurements—to permit rapid, simple, quantitative evaluation of polished metal surfaces.

Called a DORI (for Distinctness Of Reflected Image) meter, it judges the quality of the reflection by substituting a photocell for the human eye. The sample being tested becomes a mirror in a simple optical system, and sharpness of the reflected image is measured by the photocell.

The instrument works this way. Light from two narrow slits passes through a lens where it is converted to parallel rays. These rays eventually pass through a similar lens, converging again to form an image of the two slits. Midway between the two lenses, the parallel rays are reflected by the polished surface of the sample. Distinctness of the final image depends on reflective qualities of the sample, thus on smoothness of its surface.

Sharpness of the final image is evaluated by scanning it with a single slit, slightly smaller than the distance between primary slits and backed up by a photocell. If the image of the double slit is distinct, light will be concentrated, and the scanning slit




**TWO RATING METHODS,** DORI meter (top) and visual method (bottom), give same results. DORI reading shows the depth of valley between peaks as a percentage of height of the peaks. Visual method measures distance between NBS resolution chart and sample as a percentage of distance between chart and aluminized mirror. Lower photos show visual appearance of images reflected by respective samples.

will see two bright lines with very little light between. With a fuzzy image, there will be light scattered into the area between the slit images.

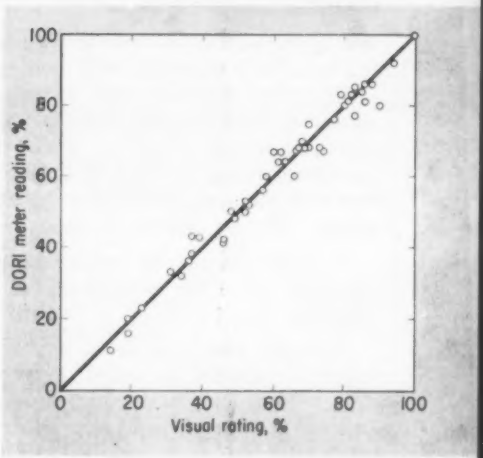
A plot of image brightness versus position of scanning slit is therefore a curve with two peaks—one for the image of each primary slit. The ratio of the height of these peaks to the depth of the valley between tells how much light has been scattered by the sample. For a perfect mirror, the ratio is 1 to 1 or 100%. Measured this way, there need be no adjustment for differences of brightness between samples. A highly polished black glass plate, which absorbs most of the light it receives, and an aluminized front-surface mirror, which reflects most of the light, will both read 100% on the DORI meter.

The scanning slit, besides locating the peaks and valleys of the image, also permits alignment of the secondary optics to adjust for tilted or misaligned samples. The sample-holder is designed to prevent such misalignment as far as is possible. A cam-operated clamp with hinged backing plate presses the polished specimen against the opening in the top of the instrument, with a pressure of approximately 750 lb. This is sufficient to flatten curved or warped sheets cut from coiled strip. Then, small errors in alignment can be handled by moving the scanning slit.

Results with the instrument compare well with results from visual grading tests. Several different kinds of visual tests are in use; to get comparative data, we chose a simple test that gives results in terms of percent and whose ratings are similar to those given by the DORI meter. The visual grading apparatus consists of an optical bench with a lighted National Bureau of Standards resolution chart at the front. The observer peers over the chart at its reflection in the sample, which is held in a movable mount in the bench. A string-and-pulley system permits the observer to pull the sample toward the chart until a selected pair of printed lines are just resolved. To remove variations in resolving power among viewers, each viewer also grades a front-surface mirror by the same method. Then, the ratio of chart-to-sample distance to chart-to-mirror distance is the rating for that sample. As with the meter, a perfect mirror is 100%; a perfectly diffuse surface is 0%.

Forty-eight samples of buffed and bright-dipped anodized aluminum sheet were ranked by both methods. For the visual ratings, values were the average rating of four viewers. Analysis of visual ratings showed a standard deviation of 6.9% image clarity among viewer. This included variations caused by nonuniform finished and warped or bent samples; warpage influenced visual readings more than it did DORI meter measurements.

Variation among meters, and variation between two readings on same meter, is small. In a test of six meters grading 35 samples, standard deviation among meters was 1.1% image clarity. It is thought that difference in meter readings is more a function of nonuniformity in samples rather than variation in instrument calibration.




**COMPARISON OF RESULTS** from DORI meter and visual tests shows good correlation. In a test of 48 samples, judged by 4 viewers, average visual ratings show good correlation with meter readings.

**EDITOR'S NOTE:** For more on surface finish see:

**The Measurement of Color and Gloss,** Feb '56, p 176—The standard tests and test instruments that help in specifying color and reflectivity of surface coatings.

**When Equipment Says It in Color,** Sep 14 '59, p 67—A guide to standard colors and color codes (in full color), and ratings for visibility under various conditions of brightness.

—Charles J Lynch

**for better isolation of shock and vibration . . .**

# NEW CONSTANT-FORCE SPRING SYSTEMS

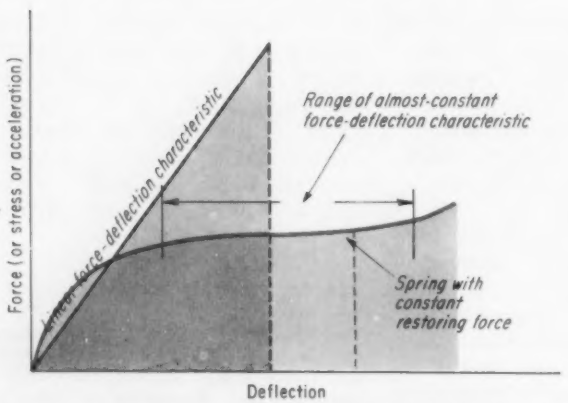
*Some are simply based on lever-and-spring, others on buckled-column combinations. They lead to glued "do-it-yourself" configurations made of rubber or plastics. These have improved the packaging and vibration-mounting of delicate instruments, and they open the way to better industrial vibration mounts.*

**ERIC E UNGAR,** *senior engineering scientist*
**KARL S PEARSONS,** *consultant*
*Bolt Beranek and Newman Inc, Cambridge, Mass*

A spring system that provides a nearly constant restoring force for a reasonably large portion of its deflection is excellent for absorbing shock and vibration—whether for mounting heavy industrial machines or for protecting delicate instruments. There are three reasons why the constant-force system is better than the familiar spring system with linear or almost-linear force-deflection characteristics:

1. It absorbs a given amount of energy with a lower maximum force (or acceleration, or stress) for a given deflection (Fig 1).

2. If the maximum shock intensity (or package-drop height) specificed in design is exceeded (when shock energy turns out to be higher than anticipated) the increase in force will not be excessive.




**1 . . COMPARISON OF TWO SPRING SYSTEMS,** each absorbing the same amount of energy (area under curves). Max force developed with constant-force spring is much less. This means a proportional reduction in stress or acceleration. The linear characteristics are typical of a helical spring. Most materials also exhibit linear characteristics at small deflections.

3. It avoids severe amplitudes at resonance, such as occur in linear systems. This is because the resonance frequency for a constant-force system varies with amplitude. Therefore, as soon as amplitudes build up, the system is no longer operating at resonance.

The term "spring systems" as used here refers to materials that are combined with levers, or cut or molded into a special shape, to adjust their spring characteristics. We employed two types of spring systems to produce constant-force characteristics:

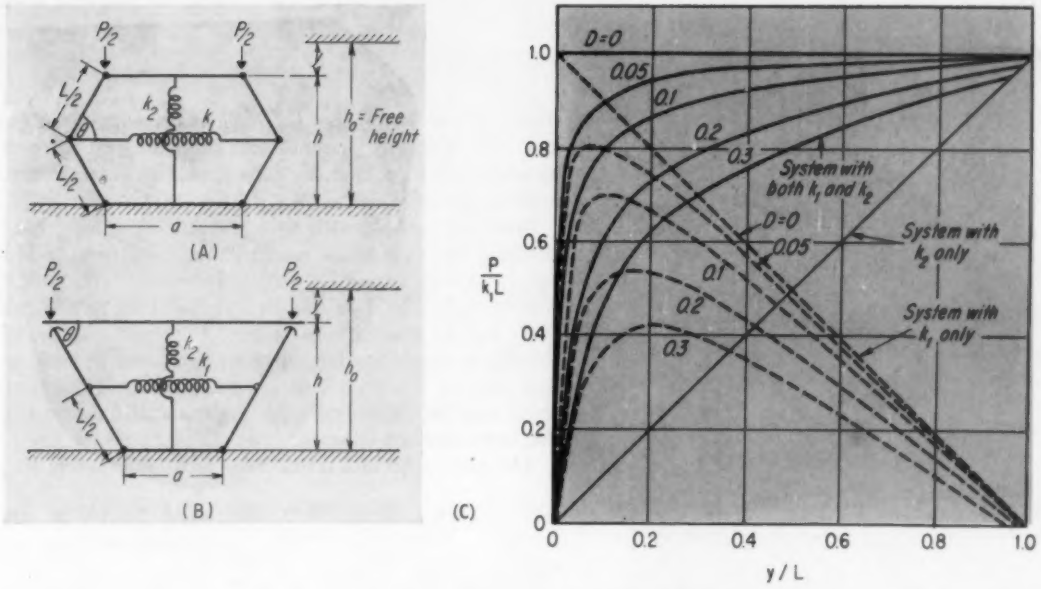
- Buckled-lever systems in which a suitable material or spring is compressed (or tensioned) between jointed levers that buckle under load.
- Columnar systems composed of a material cut or molded so as to buckle under load.

Although we developed and tested these systems for the Air Force (Air Research and Development Command, WADD) to improve the packaging (housing) of instruments and components in aircraft and spacecraft, the systems should also find wide use in vibration and shock-mounts for industrial machinery, and other applications.

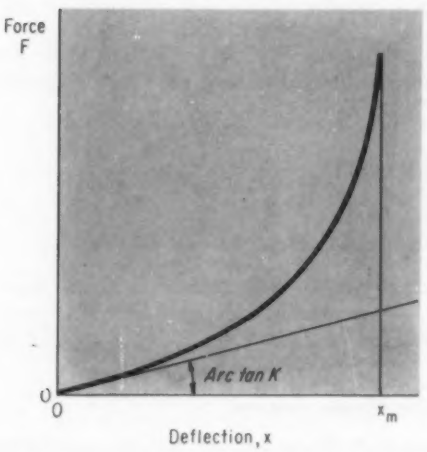
Various configurations of the buckled-lever and columnar systems are illustrated and analyzed in the article. Theoretical force-deflection equations are presented whenever possible; these were found to agree fairly closely with actual test results. Also, comparisons are made for some systems on the basis of shock and vibration tests.

### Buckled levers with linear springs

Levers that pivot to "buckle" under load can be combined with linear springs to provide constant-force characteristics over part of the deflection, Fig 2. An external load $P$ applied vertically is counteracted by two linear springs: spring $k_2$ (a compression spring) which acts directly; and spring $k_1$ (an extension spring) which acts through a linkage. This linkage reduces the effectiveness of the force in $k_1$ in counteracting $P$ as the spring deflec-




**2 . . BUCKLED-LEVER SYSTEMS,** (A) and (B), employ two linear springs: extension spring, $k_1$, and compression spring, $k_2$. Dimensionless force-deflection curves of these systems are shown in (C).




**3 . . "TANGENT" ELASTIC MATERIALS** have this force-deflection curve. Most elastomers and plastics show this stiffening effect.

tion increases. (The lines in the figures represent rigid members, the heavy dots represent hinges, and the tiny semicircles, at top end of the levers in (B), denote frictionless sliding areas.)

If spring $k_2$ were removed from the system, the force-deflection characteristics of the system would be:

$$\frac{P}{k_1 L} = \left(1 - \frac{D}{\sqrt{D^2 + \frac{2y}{L}\sqrt{1-D^2} - \left(\frac{y}{L}\right)^2}}\right)\left(\sqrt{1-D^2} - \frac{y}{L}\right) \qquad (1)$$

where

$$D = (b - a)/L$$

and where $k_1$ = spring (force-deflection) rate, lb/in.
$P$ = load, lb
$a$ = frame length, in.
$b$ = free length of spring $k_1$, in.
$y$ = deflection of the system measured from its initial free or stable height, $h_0$, in.

If, in turn, spring $k_1$ is removed from the system, then only the compression spring, $k_2$, opposes the load. This produces a force-deflection relation

$$P = k_2 y \qquad (2)$$

The force-deflection relation for the linkage with both springs can be obtained by adding the loads given by Eq (1) and (2).

Three sets of force-deflection curves are shown in Fig 2(C): The dashed curves are for a buckled-lever system with spring $k_1$ only—as defined by Eq (1); the single diagonal is for spring $k_2$ only—as defined by Eq (2); and adding the curves results in the solid-line curves for a system with both springs when the two springs have the same spring rate ($k_1 = k_2$). The curves are for five values of $D$. It can be seen from this graph that a constant-force behavior is closely approximated if $D$ is small; that is, if the spring acting in the linkage has a free length $b$ very nearly equal to the linkage spacing $a$.

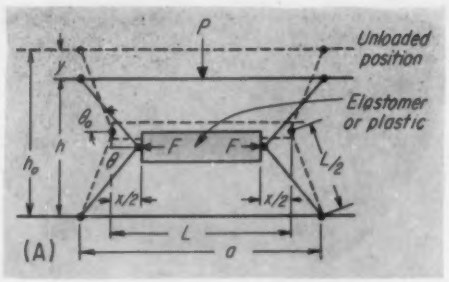
### Buckled lever with resilient materials

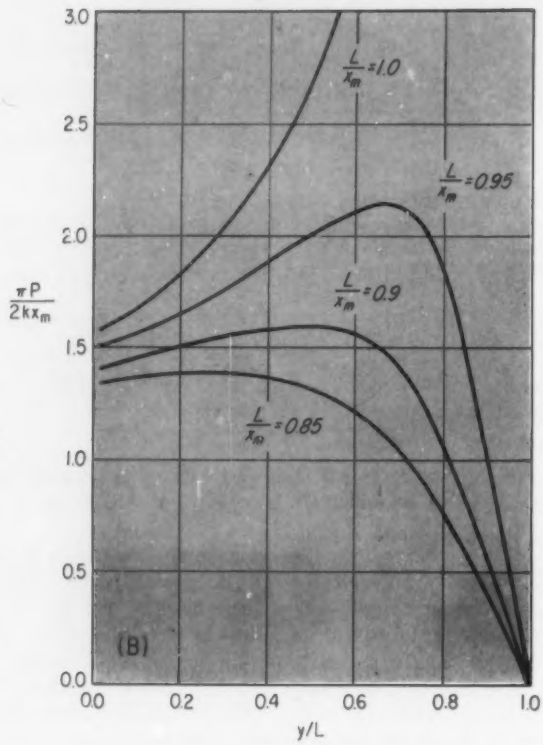
Although many springs behave linearly for quite large deflections (e.g. helical steel springs), most resilient materials tend to become stiffer with increasing strain. Rubbers and plastics, in either homogeneous or foam forms, behave linearly for small deflections, but usually develop very large forces at large strains. The force-deflection characteristics for such materials have been approximated by R. D. Mindlin, ("Dynamics of Package Cushioning", *Bell Systems Journal* 24, 353-461, July-Oct 1945) as being:

$$F = \frac{2K x_m}{\pi} \tan\left(\frac{\pi x}{2x_m}\right) \qquad (3)$$

where $K$ = initial slope of the $F - x$ curve, Fig 3 (equal to the spring rate of the material under small deflections)
$x_m$ = value of deflection $x$ where $F$ becomes very large

For a uniform material sample, $F$ can be interpreted as




**4 . . BUCKLED LEVERS** combined with resilient material (A) give wide variety of force-deflection characteristics (B), depending on stiffness characteristics of the material.

stress and x as strain. But the tangent behavior of Eq (3) may also occur for nonuniform samples, such as beer-barrel shaped ones, and the force-deflection interpretation is more generally useful.

Because a sample with this "tangent" elasticity has a climbing force-deflection rate, and the buckled-lever linkage (with only spring $k_s$) has an inherent "unstiffening" characteristic, the two can be combined to give a relatively flat force-deflection relation, Fig 4(A). Although this figure shows the tangent elastic material in compression and the levers buckled inward, a nearly identical analysis may be applied also for materials in tension, with the levers buckled outward.

The force-deflection relation for such an assembly is

$$P = \frac{2Kx_m}{\pi} \frac{\sin \theta_0 - y/L}{\cos \theta_0 + x/L} \tan\left(\frac{\pi x}{2x_m}\right) \qquad 4(A)$$

where

$$\frac{x}{L} = -\cos \theta_0 + \sqrt{\cos^2 \theta_0 - (y/L)^2 + 2\,(y/L) \sin \theta_0} \qquad 4(B)$$

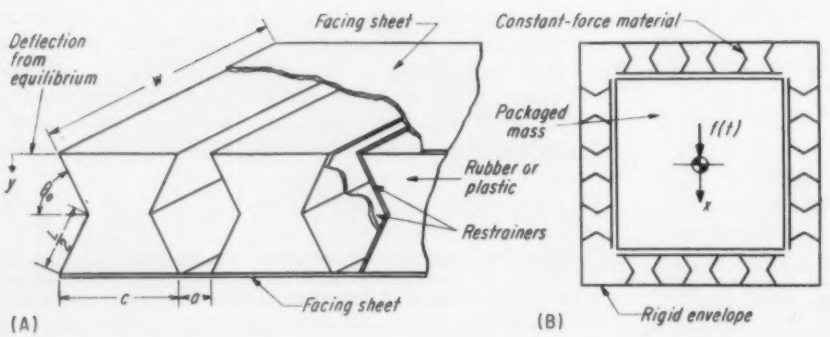
Configurations with $\theta_0 \cong 90°$ are likely to produce the most useful results. For $\cos \theta_0 = 0$, $\sin \theta_0 = 1$, Eq (4) reduces to

$$P = \frac{2Kx_m\left(1 - \frac{y}{L}\right)}{\frac{\pi}{2}\sqrt{\frac{y}{L}\left(2 - \frac{y}{L}\right)}} \tan\left(\frac{\pi L}{2x_m}\sqrt{\frac{y}{L}\left(2 - \frac{y}{L}\right)}\right) \qquad (5)$$

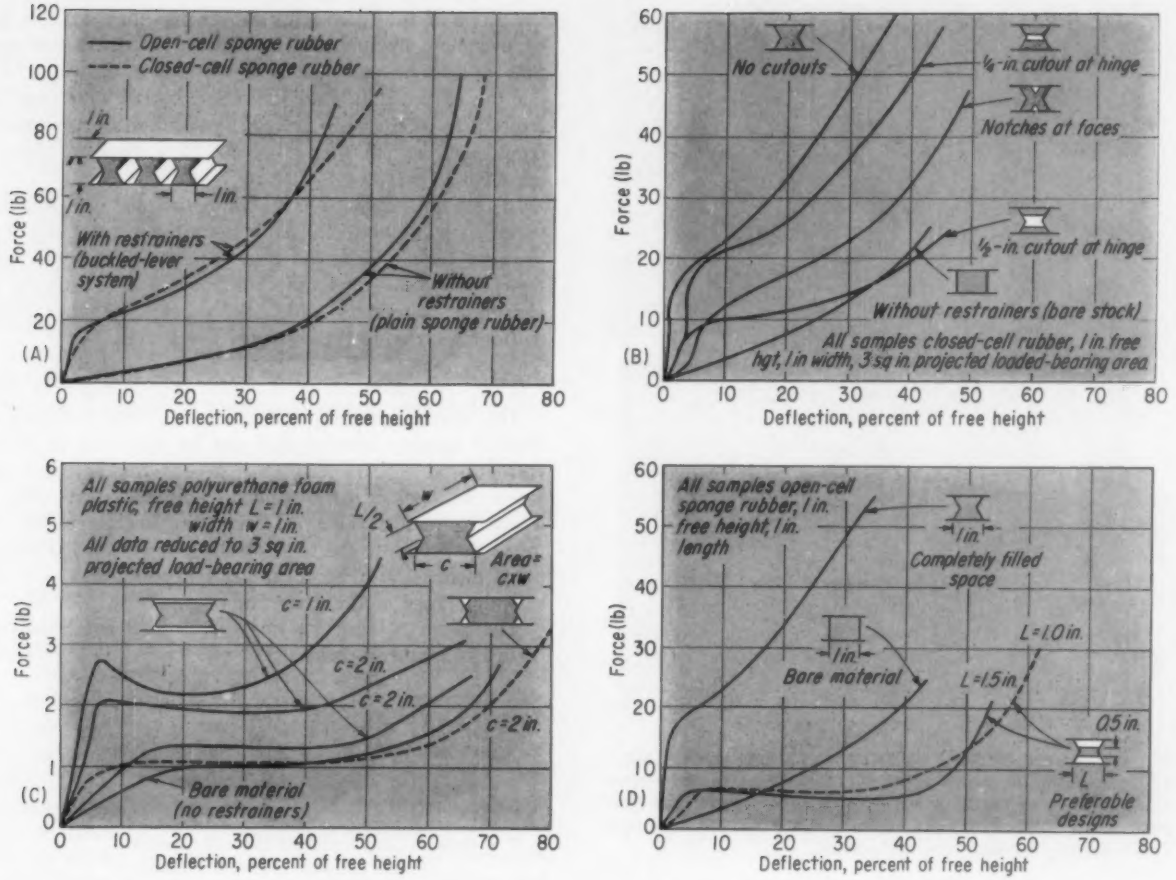
Curves of Eq (5) for several values of $L/x_m$ are shown in Fig 4 (B). A reasonably wide and nearly flat range can be obtained for values of $L/x_m$ between about 0.85 and 0.9.

### Practical buckled-lever systems

Many practical configurations are possible, employing the buckled-lever principle. One typical system, Fig 5, uses a resilient material such as rubber or plastic foam. The prismoids of the material have restrainers on the sides and facing sheets on the tops and bottoms. The restrainer may be made of any relatively rigid material, such as sheet plastic. Hinging action is provided by slits or notches in the sheets or by inclusion of actual hinges in the form of flexible fabric.




**5 . . PACKAGING MATERIAL** or vibration mount employ the buckled-lever principle: (A) construction details; (B) typical package.




**6 . . FORCE-DEFLECTION CURVES** of buckled-lever systems employing: (A) sponge rubber, (B) sponge rubber with cutouts, (C) polyurethane foam plastic, (D) tangent-elastic properties of rubber (loaded as in Fig 4).

A force applied to the facing sheets compresses the assembly vertically. Simultaneously it compresses the resilient material directly in the vertical direction (due to the facing sheets) and in the horizontal direction (due to the restrainers). The vertical compression has the same effect as spring $k_2$ of Fig 2(A); the horizontal compression has the same effect as spring $k_1$.

Results of static force-deflection measurements on one such configuration are shown in Fig 6(A). Deflection is given as percent of free height. Most test samples were 1 in. high—therefore the deflection at, say, 60% is 0.6 in. Curves for the rubber filler material (acting as a solid without restrainers) are also included. The buckled-lever system can absorb a considerably greater amount of energy for a given amount of deflection than can the plain sponge rubber. Inclusion of the restrainers changes the force-deflection curve to one that approaches the constant-force material more closely.

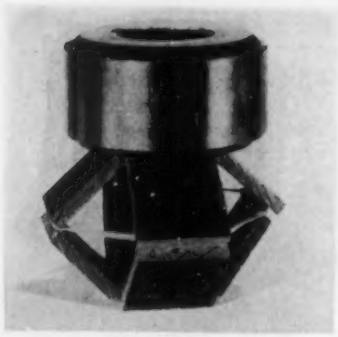
The deviation of force-deflection curves from the desired horizontal is to some extent caused by the fact that some of the filler material was subjected to large strains, and that the material stiffens considerably for such strains. Therefore, various modifications were tried; they involved removal of some portions of the filler material in regions where high strains were most likely. Fig 6(B) shows the effect of some of these modifications and indicates that this approach can result in curves with wider and more nearly flat portions.

Flatter curves can be obtained from buckled-lever configurations using polyurethane foam filler, Fig 6(C). Although even the plain foam exhibits a reasonably wide flat region, adding the restrainers increases the energy-absorption capabilities of the foam considerably for a given deflection and simultaneously widens the plateau region and increases the initial slope.

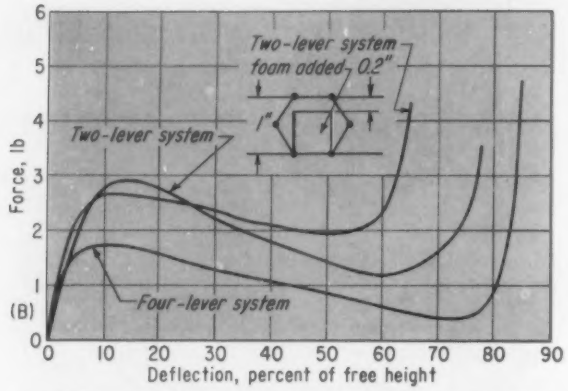
Configurations using a resilient material in compression (as previously shown in Fig 4) produced nearly flat force-deflection characteristics, Fig 6(D)—but with some construction difficulties. The resilient material buckles in compression unless a reasonable thickness is used. However, the greater the thickness, the sooner the facing sheets make contact with the material, and the smaller the range of available deflections over which nearly constant force behavior is obtained. Employing the material in tension overcomes this buckling difficulty, but brings problems of fastening it to the restrainers.

The most promising configuration with tangent-elastic properties is a two-way directional buckled-lever system using bands of rubber for the resilient effect, Fig 7(A). The stress-strain curves of this and several modifications are also illustrated in (B).

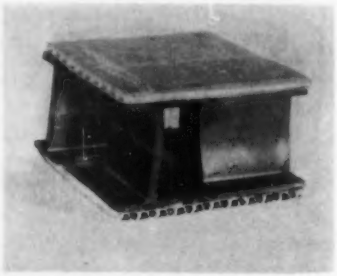
The curves show an instability evidenced by the nega-



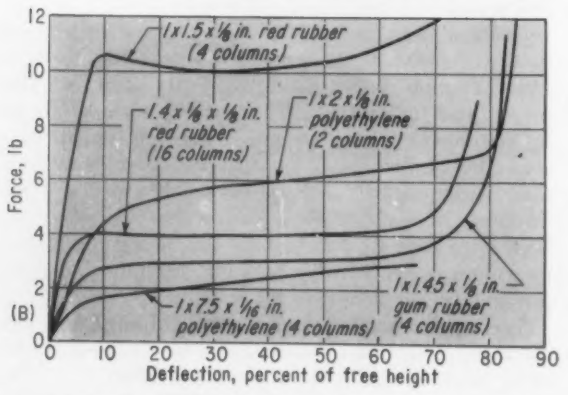
(A)




**7 . . ELASTIC-BAND BUCKLED-LEVER SYSTEMS**—(A) experimental model with buckled levers in two directions (four-lever system). (B)—force-deflection curves compare performance of two-lever and four-lever systems. Foam added to reduce negative slope.



(B)


1x1.5x⅛ in. red rubber (4 columns)
1.4x⅛x⅛ in. red rubber (16 columns)
1x2x⅛ in. polyethylene (2 columns)
1x7.5x1/16 in. polyethylene (4 columns)
1x1.45x⅛ in. gum rubber (4 columns)
Force, lb
Deflection, percent of free height
(B)

**8 . . RUBBER PLATELET-COLUMNS** in (A) are designed to buckle under load, producing the flat-plateaus in force-displacement curves (B).

tive slope of the force-deflection curve; however, this can be overcome by including a material in direct compression in the center of these configurations, as shown in (B). On the other hand, force-deflection curves with negative slopes may be useful in certain non-packaging applications requiring a system that gives way if a specified force is exceeded.

In general, buckled-lever configurations can approximate materials with constant restoring forces fairly well in many cases. However, they are subject to some practical difficulties—most important being the problem of obtaining restrainers with the proper hinging action, without weakening the assembly excessively.

### Buckled columns

The elastic instability of columns under compressive loads is another concept that can be employed to obtain constant-force characteristics. A column becomes unstable and buckles if the applied compression load exceeds a certain critical value. During the buckling that follows, the column exerts a resisting force that is nearly equal to the critical force, and nearly constant, for a considerable range of the deflection.

The Euler column formula for long, slender, uniform compression members is

$$F_c = \pi^2 C\, EA\, (r/L)^2 \qquad (6)$$

where

$F_c$ = critical load, lb
$E$ = modulus of elasticity, lb/in.²
$A$ = cross-sectional area of column, in.²
$L$ = column length, in.
$r$ = smallest radius of gyration of cross-section, in.
$C$ = constant depending on the end restraint

$$C = \begin{cases} 1 & \text{—if both ends are rounded or hinged} \\ 4 & \text{—if both ends are built-in} \\ \text{between 1 and 4} & \text{otherwise.} \end{cases}$$

We verified experimentally the applicability of Eq (6) to rubber-like materials, and the actual trends of force-deflection curves. Configurations employing columns as the buckling elements are easily designed and built to provide a wide constant-force plateau. The column-platelets are so arranged as to give lateral stability, Fig 8(A). The curves in (B) compare force-deflection performance of various configurations employing rubber or polyethylene platelets.

## SHOCK RESPONSE

Shock-isolation characteristics of a typical buckled-lever material are compared to those of plain polyurethane foam in Fig 9(A). Results were obtained from a drop-test rig. As one might expect, the buckled-lever material is "harder" and causes greater accelerations than the plain foam for very small drop-heights—but is a better shock isolator at greater drop-heights.

Drop-test results are also compared with those from static tests in (B) for materials under column loading. Materials in general are stiffer dynamically than statically, therefore it is not surprising to find that the force-deflection curves obtained from dynamic measurements lie above those obtained statically. The oscillations evident are a function of the damping inherent in the system. Greater damping obtained in actual use undoubtedly would reduce these oscillations considerably. The curves shown apply only for the particular test.

## VIBRATION RESPONSE

Comparisons between the vibration-isolation characteristics of the columnar configurations tested and those of two common foams, Fig 10, were obtained experimentally An equal thickness and volume basis was intended, but the softer foam could not support the static weight, and a greater volume of it had to be used.

Results showed good improvement—the columnar configurations reduce transmissibilities at resonance to an order of 2. In contrast, the heavy foam tested behaves virtually linearly over a considerable range, resulting in a relatively strong resonance.

Compared with the heavy foam, the larger volume of light foam behaved nearly like the columnar materials. This may be ascribed to the nonlinearity inherent in this material.

## PACKAGE-DESIGN DETAILS

Problems in the manufacture of columnar materials were relatively minor. We have had little trouble in obtaining extruded or cast rubber I-beam test samples from processors of commercial rubber and plastics.

These I-beams can be cemented to facing sheets to make up the composite material, plus lending themselves to rather convenient "glue-it-yourself" application. A given commercial I-beam section might be rated at a plateau force of so many pounds per inch of length, so that selecting the proper length would present no difficulty. To obtain a compact package, assemble various I-beam pieces of the proper total length in as closely spaced an array as possible, commensurate with the density of the packaged item. If no I-beam with sufficient deflection capability is available, the I-beam pads can be placed atop each other. Such arrays result in twice (or *n*-fold) the deflection of a single pad, with no reduction in the plateau force.

Rotations caused by shocks experienced when a package is dropped can cause excessive local deflections of the packaging materials, resulting in damage to the packaged item. To reduce damage, the package should be designed so that the line of action of the resultant restoring force always passes through the center of gravity of the packaged item. With conventional packaging materials this may be difficult to arrange. However, "glue-it-yourself" I-beams can be arranged on a given face of the package envelope so that center of gravity of their restoring forces coincides with the projection of the center of gravity of the packaged item onto that face.

**For REPRINT of above article, just check 595 on one of the Reader Service cards bound in this issue.**

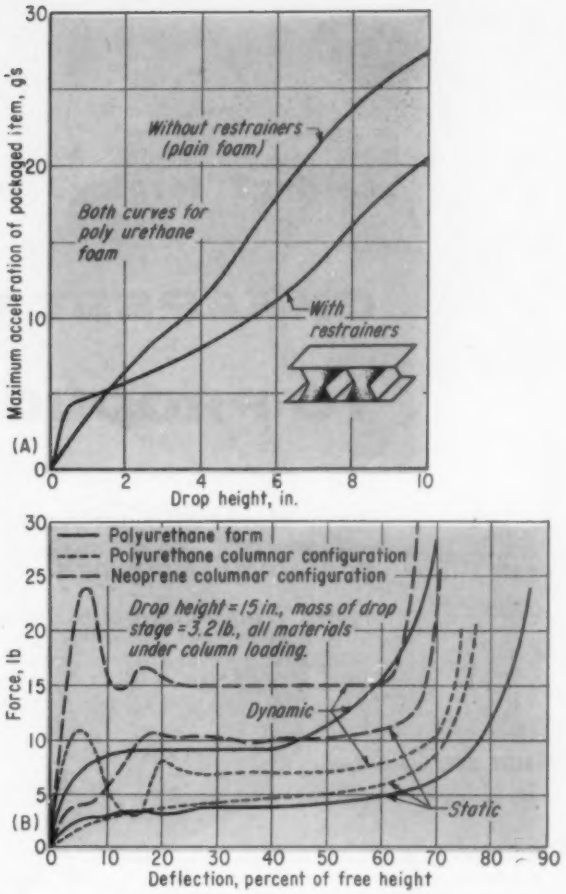
**EDITOR'S NOTE:** For other interesting devices and configurations which give constant or almost-constant force characteristics see:

**7 Applications for the Constant-force Spring,** Dec 7, '59, p 90—The Neg'ator spring at work in up-to-date applications.

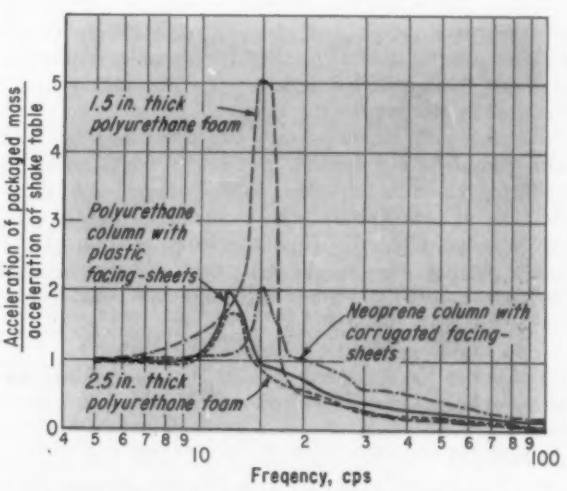
**Vibration Isolators with Zero Stiffness,** Sep 29, '58, p 52—These employ springs arranged in combinations to provide an almost-constant stiffness under shock and vibration.

**Constant-force Compression Springs,** Sep '54, p 129— Details of the Flex'ator—a compression spring with offset ends designed to buckle under load.

—Nicholas Chironis




**9 . . RESPONSE OF SYSTEMS** to shocks from drop tests: (A)—comparison between buckled-lever system and plain foam, and (B) between static and dynamic column-loading.


Acceleration of packaged mass / acceleration of shake table
1.5 in. thick polyurethane foam
Polyurethane column with plastic facing-sheets
Neoprene column with corrugated facing-sheets
2.5 in. thick polyurethane foam
Freqency, cps

**10 . . ACCELERATION TRANSMISSIBILITY** of various packaging samples.

### casting? forging? machining from solid?

# CHEAPEST WAY TO PRODUCE METAL PARTS

*This study shows the relationship between complexity of the part, quantity produced, cost of material. The data comes from cost estimates given by 30 companies for two representative parts.*

**HERBERT KEE,** *assistant editor*

If it's possible to produce a metal part by casting, forging or machining from solid stock, the choice among these methods will depend on price. And cost per piece, in turn, depends on complexity, cost of material, and quantity produced. The relative effects of these factors, was the subject of a graduate thesis at Purdue University.

The objective was to determine at what quantity various materials and production methods would pay. Drawings for two representative parts were offered to 250 companies with requests for quotations. Eighty companies responded: of these, 30 supplied complete price information which was used in plotting the cost curves.

Plotting such curves is easy but they must be used with considerable judgment, particularly when trying to estimate the costs of other parts, because each shape presents its own production problems. However, the survey is basically valid because relative position of the curves remains the same. Each process has a minimum tooling cost to write off, and this must be divided by the number of parts ordered.

Two simple parts were designed for the survey. They are shown on the opposite page: (No. 1) a flanged bushing, with a volume about 7.8 cu in.; and (No. 2) a fork-shape part, about 0.8 cu in. Prices were requested for each in quantities of 100, 500, 1000, 10,000, 25,000 and 100,000 pieces in a specific material and production process. Tooling cost was requested as a separate item.

Results are summarized below and in the sets of curves, two for each part. These curves, which plot unit cost against quantity, show:

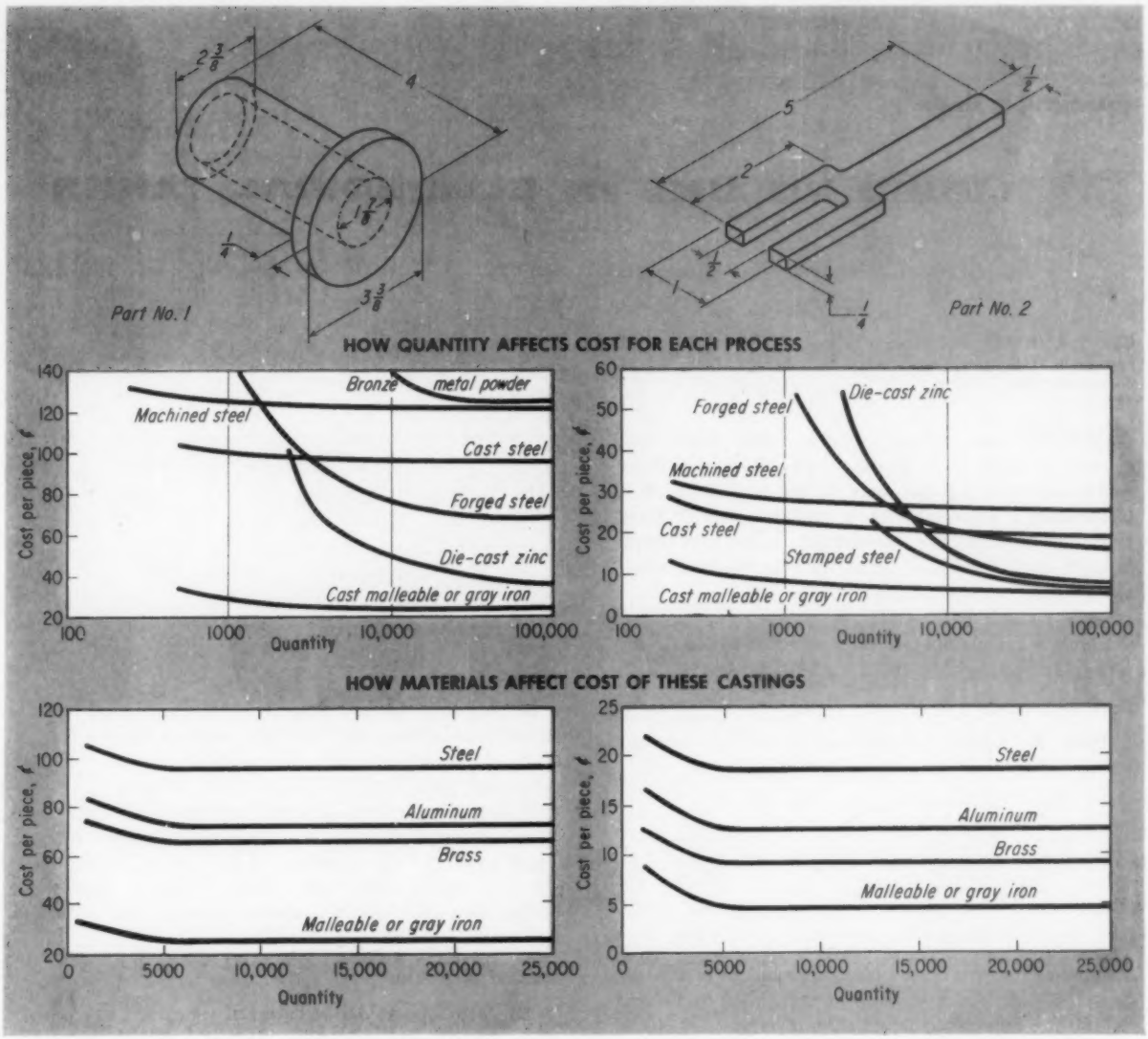
**Tooling portion of costs is small when quantities exceed** 25,000—and the price shows little decrease from then on. But where tooling is expensive, unit costs levels off at higher quantities. For example, diecast parts show some decrease in costs even up to 100,000 parts.

**Casting is cheapest process for production runs.** With a low-cost material like malleable iron, it is most economical materials-process combination for both parts studied. Malleable and gray iron castings are shown by a common curve because tooling costs are comparable. Gray iron castings are usually slightly cheaper because they do not require the furnace-annealing given to malleable castings, but malleable iron parts have the higher ductility and better machinability. These costs are given for rough castings and might be offset by machining when required tolerances are closer than those given by sand casting.

**Ease of processing can offset materials cost.** In the comparison of materials for sand castings, shown in the lower set of curves for each part, aluminum castings are revealed to be more expensive than those of brass, even though aluminum metal is cheaper on a volume basis. This is because brass is more easily cast. Similarly, brass forgings are often competitive with aluminum forgings on a per-piece basis. The cost-spread between aluminum and brass is less for the larger part because material cost is a higher proportion of the total.

Other data from the survey but not plotted in the curves show:

**Cheapest method for a single part is machining from solid**—it requires the least in tooling cost. But the temptation to continue to machine when only several more parts are needed can lead into a trap because break-even point




between machining and casting in gray or malleable irons is often as low as 25 pieces. Larger complex parts that must be built up from several machined parts may pay for patterns even if quantity is as low as 2 or 3 pieces.

**For diecastings, brass is the most expensive material.** Aluminum is cheaper here because it is readily cast under pressure and causes less die wear. Zinc, cheapest for the fork shape, was more expensive than aluminum or magnesium for the flanged bushing because of the larger volume of metal and the higher cost of zinc on a volume basis.

**Permanent-mold casting was cheaper for the flanged bushing than casting in sand.** For hollow shapes, the permanent mold eliminates need for an expendable sand core for each casting. On the other hand, permanent molds offered no advantage for the fork shape because it requires no core.

**Complexity of shape shifts costs to manufacturing.** This is because the difference in costs of these common materials is small (10 to 30 cents per lb). But the cost of larger parts reflects a higher percentage of cost of the materials.

**EDITOR'S NOTE:** Other articles on production economics and cost estimates:

**Estimating Costs of Hi-temp Parts,** Feb 1 '60, p 58—A handy chart guide for 16 high-temperature alloys. It takes in complexity of the part and method of manufacture.

**Cutting Costs on Prototypes and Small Lots,** Mar '56, p 169—How to reduce costs without restricting design or compromising on standards.

**Engineering Economics,** Feb '55, p 187—Competition calls for better methods to evaluate technical effort in terms of dollar return.

**Breakeven Charts,** Aug '53, p 170—You can use them to determine whether the product should be made.

**A Simple Approach to Cost Estimating,** July '53, p 178—How to determine manufacturing costs of a product still in early stages of design. This method can be easily developed from records of any company.

**Cost-estimating Principles and Practices,** Mid-Oct '52, p A-2—Fundamentals of estimating cost of parts, with examples.

# LIQUID VOLUME IN ELLIPSOIDAL TANKS

It solves for special versions and a sphere as well as for the pure ellipsoid.

**CDR S R HELLER JR, USN**
*Portsmouth Naval Shipyard*
*Portsmouth, NH*

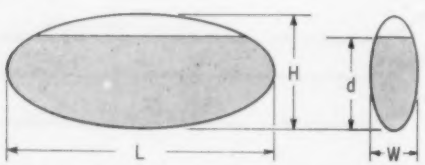
All tanks aren't cylinders. And many tanks with cylindrical sides have dished ends. Most of these odd-shape tanks are ellipsoids of one sort or another. Calibrating a sounding rod or gage for one of them takes sets of repetitive calculations. The nomograph at right finds volume of liquid in a partly filled ellipsoidal tank, solving the equation:

$$V = \pi\, LWH\, (d/H)^2\, [1 - \tfrac{2}{3}\, (d/H)]/2$$

Since the equation is for a general ellipsoid, the nomograph applies to several kinds of tanks.

### Pure ellipsoids

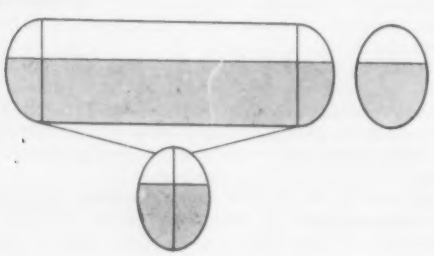
Here, the horizontal and vertical cross-sections are both ellipses.




**Example:** A pure ellipsoid tank has a height of 200 in.; length, 25 in.; width, 150 in. When filled to a depth of 160 in., how much liquid does it hold?

**Solution:** (1) Draw a line from $L = 25$ on the left scale to $W = 150$ on the center scale. (2) Draw a second line from $H = 200$ on the left scale through the intersection of the first line with the index line to the center scale. (3) Then connect the arrowhead on the center scale to $d/H = 160/200 = 0.8$ on the right scale. (4) Finally, draw a line from the intersection of the second line with the center scale, through the intersection of the third line with the index line, to the answer on the right scale, volume $V = 1523$ gal.

### Dished ends



**SYMBOLS**

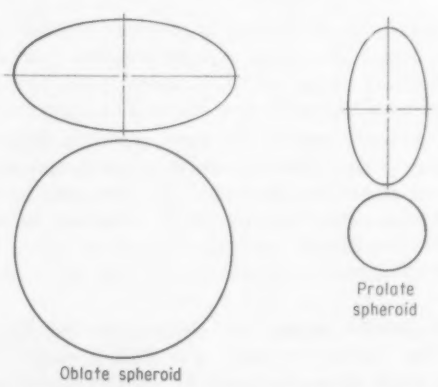
$d$=Depth of liquid, in.
$H$=Height of tank, in.
$L$=Length of tank, in.
$V$=Volume of liquid in tank, gal.
$W$=Width of tank, in.

If the ends of a horizontal cylindrical tank are hemiellipsoids, then the two ends together make a full ellipsoid. Simply add the volume of liquid held in the cylindrical portion to that held in the ellipsoid.

When a hemiellipsoid is the bottom of a vertical cylindrical tank, consider it an ordinary ellipsoid until liquid rises into the cylinder. When liquid level rises into the top section, find volume of empty portion of the ellipsoidal end and subtract from volume of the full tank.

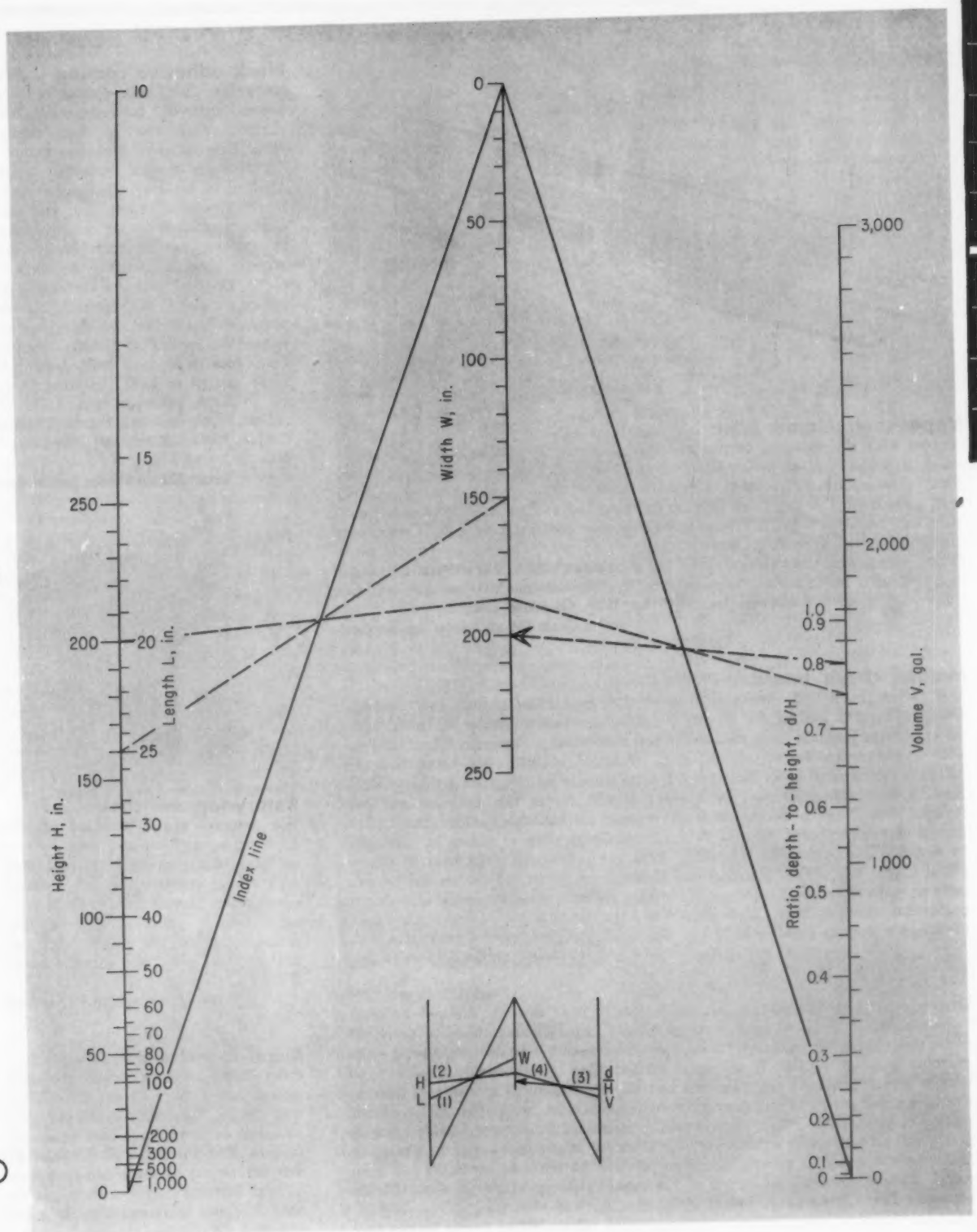
### Special ellipsoids

An oblate spheroid is a flattened sphere. Find volume in usual way, remembering that length $L$ equals width $W$, and height $H$ is less than either.




A prolate spheroid is longer vertically than a perfect sphere. Length and width are still equal, but height is greater than both. Procedure is the same as above.

When solving for a sphere, the height, width and length are all equal.


Height H, in.
Length L, in.
Index line
Width W, in.
Ratio, depth-to-height, d/H
Volume V, gal.
0
10
15
20
25
30
40
50
60
70
80
90
100
200
300
500
1,000
250
150
100
50
0
50
100
150
200
250
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
3,000
2,000
1,000
0
H
L
(1)
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W
(4)
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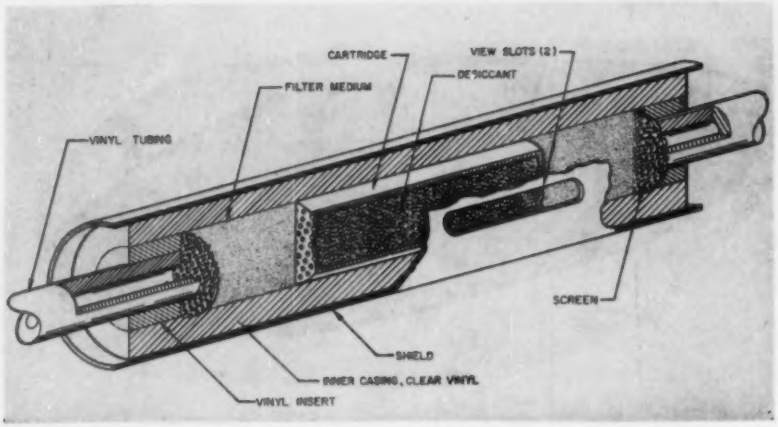
V

# SIGNIFICANT COMPONENTS MATERIALS, PROCESSES




## Vapor-contaminant filter . . .

for use with air, nitrogen, oxygen and similar gaseous matter in pressure lines, is designed primarily as an in-line filter, working in conjunction with main, heavy-duty filter. Five-in.-long unit consists of reusable dessicant filter encased in a plastic shell, with molded vinyl tubing, 4 in. long on receiving end and 44 in. long on other end. Both ends are fitted with NPT brass fittings. Entire unit, weighing ½ lb, is encased in aluminum shell. Operating pressure is safe to 75 psi. Can be rejuvenated on a heated manifold at temperatures up to 120 F until such time that dessicant becomes saturated with oily residue. Manufactured by Servomechanisms, Inc and available off-the-shelf from A Biederman Inc, 1045 Air Way, Glendale, Calif.

**Circle 300 on Reader Service Card**

## Molded circuit board . . .

is a 2-sided circuit with electroplated conductors in recessed grooves and contoured holes. Molded of any number of plastic materials, circuit reportedly has 30% higher current-carrying capacity than standard etched conductors of same thickness. A ⅛-in.-wide conductor handles up to 100 amp. Recessed channels and hourglass-shaped holes are incorporated in molding process, eliminating need for piercing dies. Whole board is first made conductive by applying minute copper film to board and hole linings. Board next is electroplated with copper to thickness specified and lead-tin then is electroplated over copper. Possibility of discontinuity is said to be eliminated by fact that conductors and hole lining form one continuous, even layer of electroplated copper and solder. Physical and electrical properties are determined by base molding material specified. Two-sided circuitry available at sq in. cost comparable to single-sided etched circuitry. Delivery in 4 to 8 wk, depending upon molds complexity. Machined prototypes available in 72 hr. Combined Electronics Inc, Cicero, Ill.

**Circle 301 on Reader Service Card**

## Underwater transducer . . .

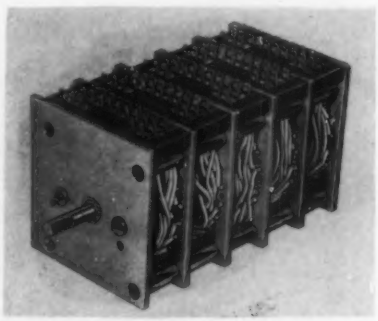
operates at up to 60-psi water pressure and over a frequency range from 10 to 10,000 cycles per sec. Below resonance, its response is a constant −82 db; reference, 1 v per microbar (−90 db into 60 ft of coaxial cable). Unit is substantially nondirectional over its normal frequency range and can be used as a transmitter as well as a receiver. Converts sound energy to electrical energy as sound acts on two pistons which drive a pile up of piezoelectric disks. Reproducible performance makes unit suitable for array design and permits circuit standardization. With 60 ft of cable, device weighs 11 oz in brass piston design, 9 oz with aluminum pistons. Measures 1¾ in. in dia and ½ in. thick. Sample quantities are priced at $24 each. Delivery within 30 days. Clevite Ordnance Div, Clevite Corp, 540 E 105th St, Cleveland.

**Circle 302 on Reader Service Card**

## Black adhesive coating . . .

for metals, glass, some plastics and most porous materials, conducts away static charges. Each coat of the synthetic-rubber-base adhesive produces approx 2 mil thickness of static-conducting surface. Applied by brushing, elastic coating resists oil, gasoline, water, heat and cold. Corrosion-resistant coating can be obtained by applying two or more brush coats, allowing about 1 hr drying time between coats. One gal provides one-coat cover for approx 200 sq ft. Reportedly becomes progressively tougher and more heat resistant over period of months. Available from stock in medium brush viscosity at $6.25 per gal in 1-gal quantities; $6 per gal in 5-gal quantities; and $5.75 per gal in 54-gal drums. Schwartz Chemical Co Inc, 50-01 2nd St, Long Island City 1, NY.

**Circle 303 on Reader Service Card**



## Rotary-tap switches . . .

have terminal boards mounted on sides for easier wiring. Available with one, two or three boards mounted on each deck, with wiring completed during assembly of switches. Supplied in either paper- or glass-base epoxy, units have knee-action rotors and solid-silver alloy contacts and slip rings. Daven Co, Livingston, NJ.

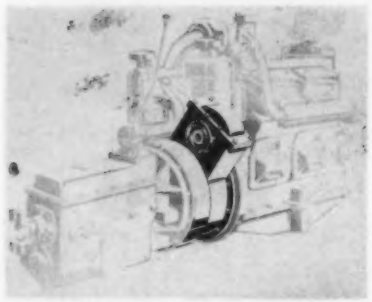
**Circle 304 on Reader Service Card**

## Metal-to-metal adhesive . . .

is dry (100% solids) modified epoxy resin system that contains no solvent or cloth-type carrier. Requires no priming agent on metal or honeycomb core faying surfaces to effect a strong bond. Sheet of dry film can be cut to shape and interposed directly between metal surfaces, to be bonded. Cures in approx 1 hr at 350 F and needs no post cure. Supplied in 18-in.

wide continuous rolls weighing approx 0.055 lb per sq ft, adhesive produces a glue line with an average thickness of 0.005 in. Additional plies can be used for extra strength and merge into single homogeneous layer during cure cycle. Material has shear strength of 6500 psi at room temperature and at −67 F. At 170 F its shear strength is 3100 psi. **Narmco Materials, Div of Narmco Industries Inc, 600 Victoria St, Costa Mesa, Calif.**

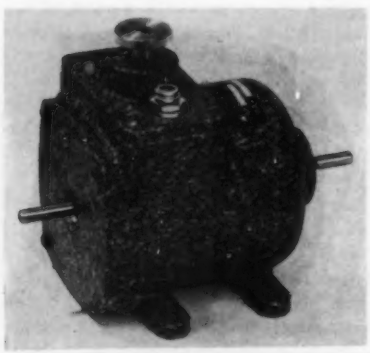
**Circle 305 on Reader Service Card**



## Flywheel power-takeoff unit

delivers 200 hp directly from engines rated up to 400 hp. Heavy-duty unit mounts independently between engine flywheel and master clutch, and power can be taken off even when clutch is disengaged. Straight-through shaft transmits engine power to master clutch and transmission, whereupon three helical gears deliver power from main shaft to power takeoff output shaft. The 12½-in. long PTO can be adapted to any gasoline or diesel engine. Standard mounting—front and rear—is provided by SAE Nos 1 and 2 housing. Speed ratio of standard model is 1.24:1. Rotation at 30° increments positions unit for specific jobs. Delivery in 3 to 4 wk. **Cotta Transmission Co, Rockford, Ill.**

**Circle 306 on Reader Service Card**



## Miniature torque pickup . . .

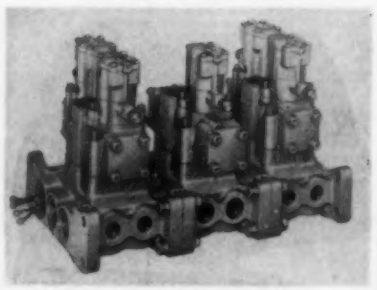
for measurements in the in-oz area, has readings from stall to 20,000 rpm. Five models are available in full scale capacities of from 50 to 1000 in.-oz at ¼% accuracy. Can be used with belt or gear drives. Brush holder and lifter is single assembly that can be changed by removing two screws. **Lebow Associates Inc, 14857 W Eleven Mile Rd, Oak Park 37, Mich.**

**Circle 307 on Reader Service Card**

## Medium-impact phenolic . . .

is two-step, cellulose-reinforced compound which can be compression-, transfer- or plunger-molded, and is suitable for use in all types of automatic molding equipment. Molds to a lustrous, black finish with following properties: bulk factor, 2.8 to 1; impact strength, min 0.4 ft lb per in. of notch; flexural strength, min 11,000 psi; tensile strength, min 8000 psi, water absorption rate, 0.5%; and short-time dielectric strength, min 300 vpm. **Rogers Corp, Rogers, Conn.**

**Circle 308 on Reader Service Card**



## Multiple manifold sub-base

can be used individually or ganged to permit mounting of up to ten ¼-in., 4-way, plug-in valves. Has common inlet and exhaust ports and built-in plug connector which complete electrical connections automatically. Made of cast aluminum, unit is available with cylinder ports tapped ¼ or ⅜ in. NPT for side or bottom connection. Common inlet and exhaust ports are tapped 1 in. NPT. **Bellows-Valvair, Div of IBEC, 454 Morgan Ave, Akron 11, Ohio.**

**Circle 309 on Reader Service Card**

## Filter-screen trap . . .

consists of 1-in.-dia stainless steel tube-shape magnet enclosed in 2-in.-dia perforated bronze filter screen with either 0.020 or 0.030-in. dia holes. Both are housed in bronze casting rated for 350 lb pressure which has 2-in. pipe thread inlet and outlet. Permits oil to be passed over magnet first and then through filter or vice versa. Priced at approx $100. **Briez Mfg Co, 1945 Grove Dr, Erie, Penna.**

**Circle 310 on Reader Service Card**

## Panel fastener . . .

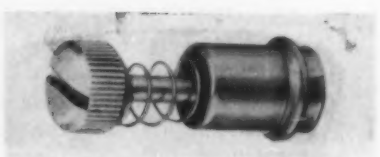
has two parts—molded plastic grommet and plunger—both of which remain captive in removable panels, doors, drawer fronts and other sections. Fastener is installed by placing grommet into standard drilled hole and inserting plunger within grommet. Assembly in the fixed panel then is placed against panel to which it is to be connected. As holes line up (grommet floats for misalignment of holes), pressure on plunger expands fingers of grommet through hole, making grommet on the inside a greater diameter than hole itself. Retracting plunger collapses fingers and allows fastener to be removed. Single size fastener accommodates wide range of thicknesses to be fastened together. **Hartwell Corp, 9035 Venice Blvd, Los Angeles 34.**

**Circle 311 on Reader Service Card**

## Flow-regulating valve . . .

is said to provide extremely fine adjustment in low flow ranges. Flow increases from zero to only about 10% of potential during first 360° rotation of valve adjusting sleeve, while successive rotations of the sleeve produce flow volumes of approx 30, 65 and 100%. Valve's internal design permits flow equal to full pipe area in both directions. Knife-edge variable orifice reduces flow distortion caused by viscosity changes in working medium. Unit, available in ⅛-, ¼-, ⅜- and ½-in. pipe sizes, operates in −40 to 250 F range and accomodates working air pressure to 250 psi and oil pressure to 1000 psi. Has no internal springs and is said to be rustproof. **Mead Specialties Co, 4114 N Knox Ave, Chicago 41.**

**Circle 312 on Reader Service Card**



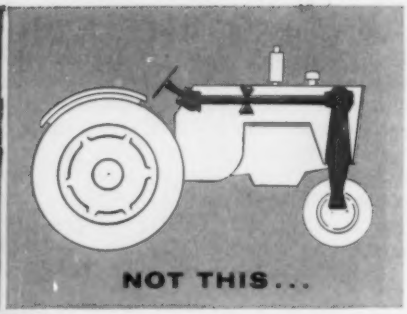
## Spring-loaded panel fastener

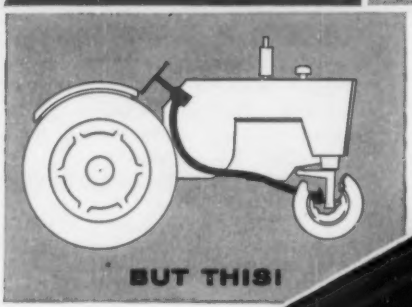
automatically pops into full retraction when disengaged. Remains in that position, providing clearance for panels to move laterally. Special stand-off, flanged into door or chassis panel, holds screw assembly. Available in seven thread sizes

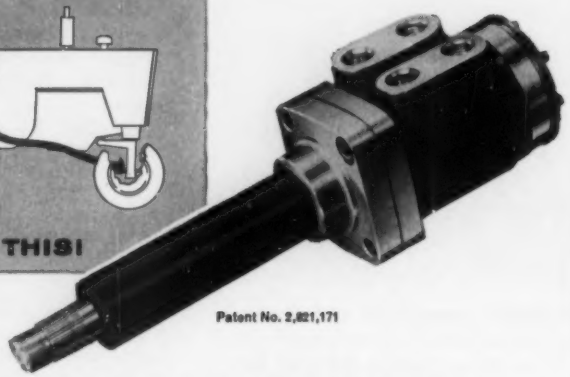
continued on page 66

# Char-Lynn "ORBITROL"®

PROVIDES FULL FLUID STEERING *without* MECHANICAL LINKAGE




The New **ORBITROL is a completely integrated fluid steering control** system that eliminates steering gear boxes and mechanical linkages to the axle.

Only **ORBITROL provides remote rotary servo control** with sensory direction and delivery measurement within the same unit . . . the **ideal** concept for modern self-propelled vehicles.

**ORBITROL also features integral manual steering** for use in emergency or "engine-off" conditions . . .

When live hydraulic power is not available the ORBITROL automatically becomes a rotary hand pump and directs fluid to move the actuator in either direction when the steering wheel is rotated.

The ORBITROL is ideally suited for controlling conventional steering systems, multiple axles and dual control installations.

Contact CHAR-LYNN today . . . our engineers will be pleased to submit recommendations relative to your particular application or needs.

Char-Lynn

CHAR-LYNN CO.
Hydraulic Horsepower Products
Dept. PE-3
3843 26th Avenue South
Minneapolis, Minnesota
Parkway 1-8761




from 8-32 to ¼-28 and three head sizes, with or without slots. **Southco Div, South Chester Corp, Lester, Penna.**

**Circle 313 on Reader Service Card**

## Air-operated valves . . .

for on-off use with ⅛-, ¼-, ⅜- and $\frac{5}{16}$-in. tubing valves, operates at pressures up to 5000 psi. Available in both air-to-open and air-to-close designs and are suitable for systems where space is limited. **Autoclave Engineers Inc, 2947 W 22nd St, Erie, Penna.**

**Circle 314 on Reader Service Card**

## Tape magazine . . .

holds up to three recordings in individual cartridges and requires no threading. Each cartridge, containing 40 ft of ¼-in. tape in random distribution, has four discrete tracks for prerecorded programing or information. Standard tape, with duration of 2 minutes, provides from 4 to 12 messages. With modified tape, messages up to 4 minutes long are possible. Tape speed is 3¾ ips. Device originally designed for automatic announcements to jet airline passengers. **United Data Control Inc, Pasadena, Calif.**

**Circle 315 on Reader Service Card**

## Ring sprockets . . .

are for chains from 1.5 through 4.063 in. pitch with diameters from 44 through 106 in. and bore sizes from 36 through 100 in. Include those for either welding or bolting in-place, and are available as solid rings or as split units with match markings for reassembly. From stock. **American-Marietta Co, Milwaukee 1.**

**Circle 316 on Reader Service Card**

## Miniature indicator light . . .

combines momentary action pushbutton switch with transistor circuitry and complete neon indicator in single unit. Neon lamp is transistor-controlled from small signals which eliminate need for high voltages in logic circuits. Integral switch has gold-plated contacts with life expec-

continued on page 70

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**RECORDAK precision 35mm microfilm images *more than meet DOD requirements*—give a minimum of 120 lines per mm resolution at 30-to-1 reduction ratio.**

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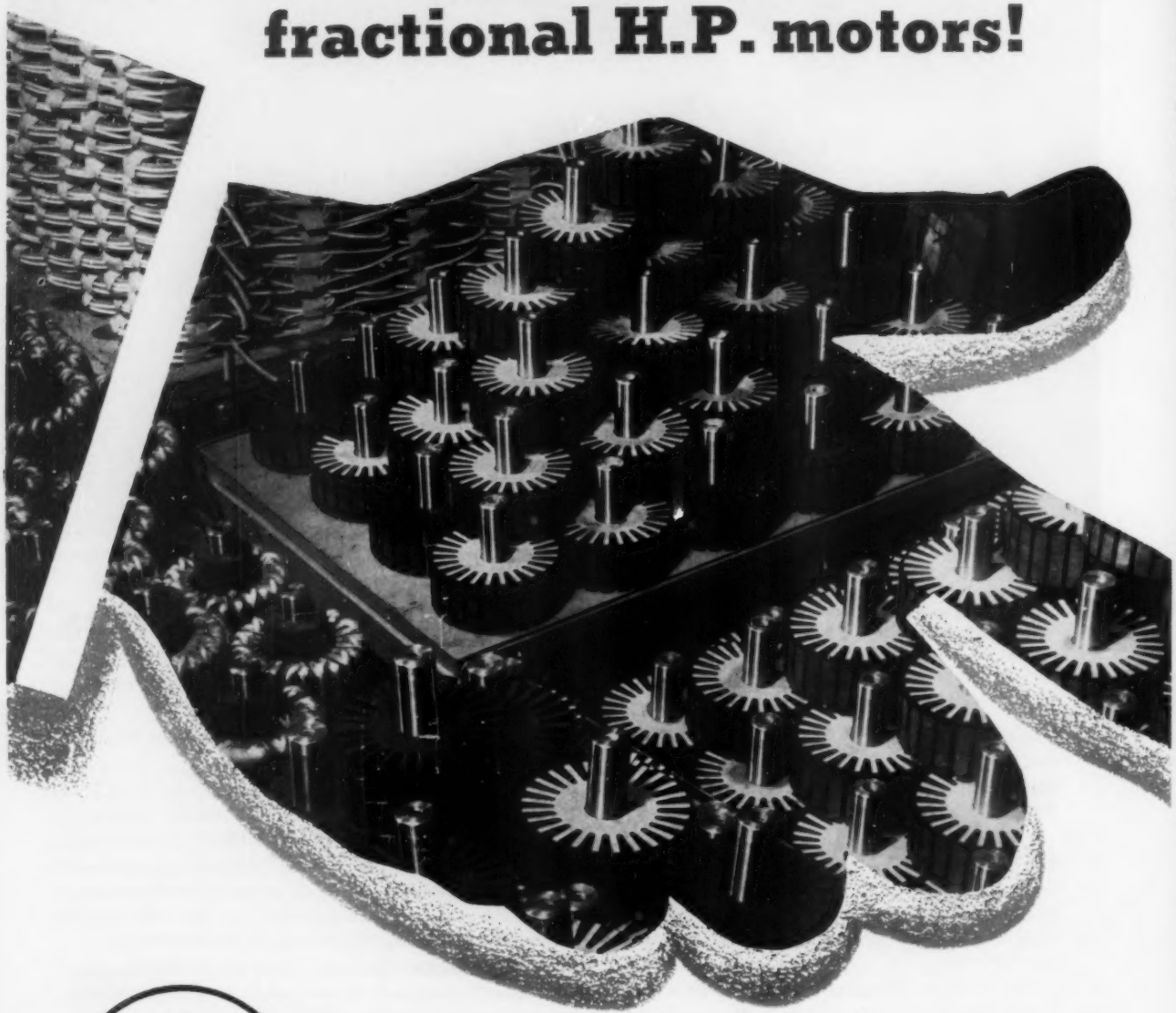

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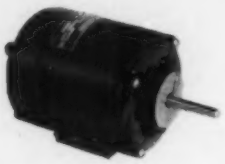
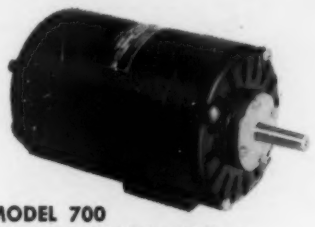


**MODEL 29-500**
TYPE: Universal AC/DC or Shunt.
DIAMETER: 3-5/16.
LENGTH: 4-11/16 to 5-19/32.
H.P.: Continuous: Series—1/6 @ 10,000 R.P.M.
Shunt or Compound—1/12
Intermittent Series—1/4 @ 10,000 R.P.M.
Shunt or Compound—1/6.
SPEED: No Load: Series—15,000 R.P.M.
Shunt or Compound—12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.

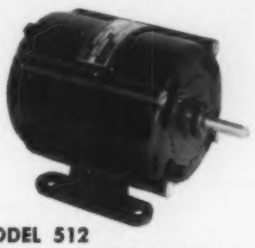


**MODEL 700**
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 3.800".
LENGTH: 5-7/64". to 6-7/64".
H.P.: Continuous: Series—1/4 @ 10,000 R.P.M.
Shunt—1/8.
Intermittent: Series—1/2 @ 10,000 R.P.M.
Shunt—1/4.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—5000 to 10,000
Shunt—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC/DC.
Shunt—6 to 230V. DC.
BEARINGS: Grease sealed ball bearings.

**MODEL 1100**
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-13/16". LENGTH: 3-9/16".
H.P.: Continuous: Series—1/50 @ 10,000 R.P.M.
Shunt—1/50.
Intermittent: Series—1/15 @ 10,000 R.P.M.
Shunt—1/15.
SPEED: No Load: Series—15,000 R.P.M. approx.
Shunt—3500 to 12,000 R.P.M.
Full Load: Series—3000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type, or Grease Sealed Ball Bearings.

**MODEL 243**
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-17/32.
LENGTH: 3-15/16.
H.P.: Continuous Series—1/12 @ 10,000 R.P.M.
Intermittent—1/8 @ 10,000 R.P.M.
SPEED: Full Load Speed:
Series—5000 to 10,000 R.P.M.
Shunt—2000 to 7000 R.P.M.
VOLTAGES: Series—12 to 230V. AC/DC.
Shunt 6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with oil reservoir.

**MODEL 200**
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 1-11/16".
LENGTH: 2-11/16".
H.P.: Continuous Series—1/200 @ 10,000 R.P.M.
Shunt—1/200.
Intermittent: Series—1/75 @ 10,000 R.P.M.
Shunt—1/75.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—15,000 R.P.M.
Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—3000 to 10,000 R.P.M.
VOLTAGES: Series—6-115V. AC/DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.



**MODEL 512**
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-3/8". LENGTH: 4-3/4".
H.P.: Continuous Series—1/10 @ 10,000 R.P.M.
Shunt—1/12.
Intermittent: Series—1/3 @ 10,000 R.P.M.
Shunt—1/6.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: 5000 to 10,000 R.P.M.
Shunt: 1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type.

## Mail this coupon now for complete specifications

Shown here are just a few of the Universal and dc motors in the complete, competitively priced Howard line. Our large selection of standard models, a file of over 130,000 specs and new, modern, semi-automated production facilities assure you of the motor to meet your requirements, the right price and timely delivery.

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☐ MODEL 29-500 ☐ MODEL 512 ☐ MODEL 1100

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tancy of over 500,000 operations at rated current. Unit's operating and temperature storage range is —40 to 149 F at 95% humidity. Available in 20 models to fit $\frac{1}{16}$ to $\frac{1}{8}$ in. and $\frac{5}{64}$ to $\frac{1}{16}$ in. panel thickness. Lights mount from rear with single knurled nut and lock washer in $\frac{3}{8}$-in. hole on centers as close as $\frac{5}{8}$ in. Lens come in transparent red, amber or white and clear. **Transistor Electronics Corp, 3357 Republic Ave, Minneapolis 26.**

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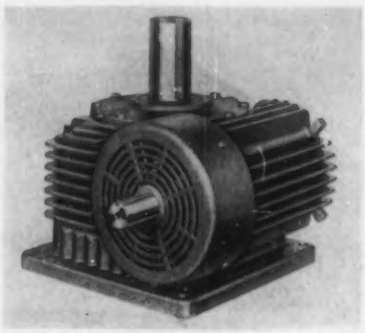


## Vertical speed reducers . . .

are available in nine sizes, ranging from 3 to 12-in. center distances. Ratios extend from 4½:1 to 95:1; ratings are fractional to 175 hp. Fan-cooled worm gear units have one-piece finned housings and incorporate dry well around output shaft, extending above oil level, to prevent oil seepage found in reducers with downward shaft extensions. **Cleveland Worm & Gear Div, Eaton Mfg Co, 3300 E 80th St, Cleveland 4.**

**Circle 318 on Reader Service Card**

## Flowmeter and filter . . .

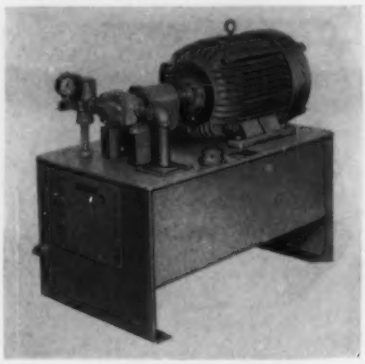
gives warning if filter becomes clogged. Light automatically appears when liquid flow falls below preset volume. Unit can be set to turn on light or to turn off power to equipment until filter is cleaned or replaced. **Capital Engineering & Mfg Co, 5837 S Ashland Ave, Chicago 36.**

**Circle 319 on Reader Service Card**

## Low-pressure-sensing switch . . .

handling a max set pressure of 7 psig, has a deadband of only 2 in. of water and repeatable accuracy of ±0.5%. Capsule-type sensing element reduces any change in pressure set point by thermal reaction over operating range of —65 to 300 F. Weighs approx 2 oz and occupies 3 cu in. of space. A SPDT snap action switch, enclosed in the cylindrical housing, can handle a current of 7 amp at 115/230 v ac. Available with AN electrical connector, cabled leads or solder terminals. **Pamer Electronics Co Inc, Sub of Hoke Inc, 1 Tenakill Park, Cresskill, NJ.**

**Circle 320 on Reader Service Card**



## Single-pump power units . . .

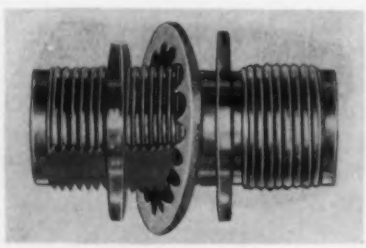
are for 1000- and 2000-psi hydraulic service. Eleven of 13 models available can be converted to 2000-psi units by installing additional hp motors. Have reservoir capacities from 15 to 60 gal and pump capacities to 35 gpm. Standard units are equipped with separate relief valve and incorporate 1800-rpm motor. **Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.**

**Circle 321 on Reader Service Card**

## High-torque servomotor . . .

is small (1 in. long), light (0.7 oz) Size 5 unit capable of 0.12 oz-in. torque at stall and 47,000 rad/sec² torque to inertia ratio. Operates continuously at —67 to 257 F and has no-load speed of 9500 rpm min. Rotor moment of inertia is 0.18 gm-cm²; time constant, 0.020 sec; and reversing time, 0.034 sec. Rated voltage at 400 cps is 26 v also available in 18 or 33 v); average input current at stall, 0.08 amp; and average input power at stall, 1.7 w. Corrosion-resistant materials are used throughout. **John Oster Mfg Co, Avionic Div, Racine, Wis.**

**Circle 322 on Reader Service Card**



## Firewall connectors . . .

withstand 2000 F without losing firewall integrity. Have nominal 50-ohm characteristic impedance. From stock. **Gremar Mfg Co Inc, Wakefield, Mass.**

**Circle 323 on Reader Service Card**

## Encapsulated reed relays . . .

have electrostatic shields, made of tubular metallic foil, which surround their glass-sealed switches and extend through epoxy encapsulation with wire lead for grounding. It is said to effectively isolate reed contacts from stray electrical noise or random pickup of unwanted signals. Relays are available in 1-, 2-, 4-, 12- and 20-pole types. Any or all poles can be shielded. **Struthers-Dunn Inc, Pitman, NJ.**

**Circle 324 on Reader Service Card**

## Ball floats betwen valve seats . . .

reportedly making a tighter seal as it is forced against downstream seat by increasing pressure. Pressure at upstream seat then is equalized by permitting fluid to get behind it. Seats seal regardless of direction of flow. Valve is installed in only two steps. Union ends are either screwed or welded onto pipe ends, and one-piece valve body then is assembled to union nut. Requires no nuts, bolts or extra union in line. Large port opening in ball permits unrestricted flow, while dual seats eliminate all metal-to-metal contact. Available in stainless steel, carbon steel or brass and in eight sizes, ¼ to 2 in. Max pressure rating for all sizes with buna-N and neoprene seats is 300 psi. Teflon seats are rated to 600 psi for 1 to 2-in valves and to 1000 psi for ¼ to ¾-in. sizes. **Clayton Mark & Co, 1900 Dempster St, Evanston, Ill.**

**Circle 325 on Reader Service Card**

## Probe-type level control . . .

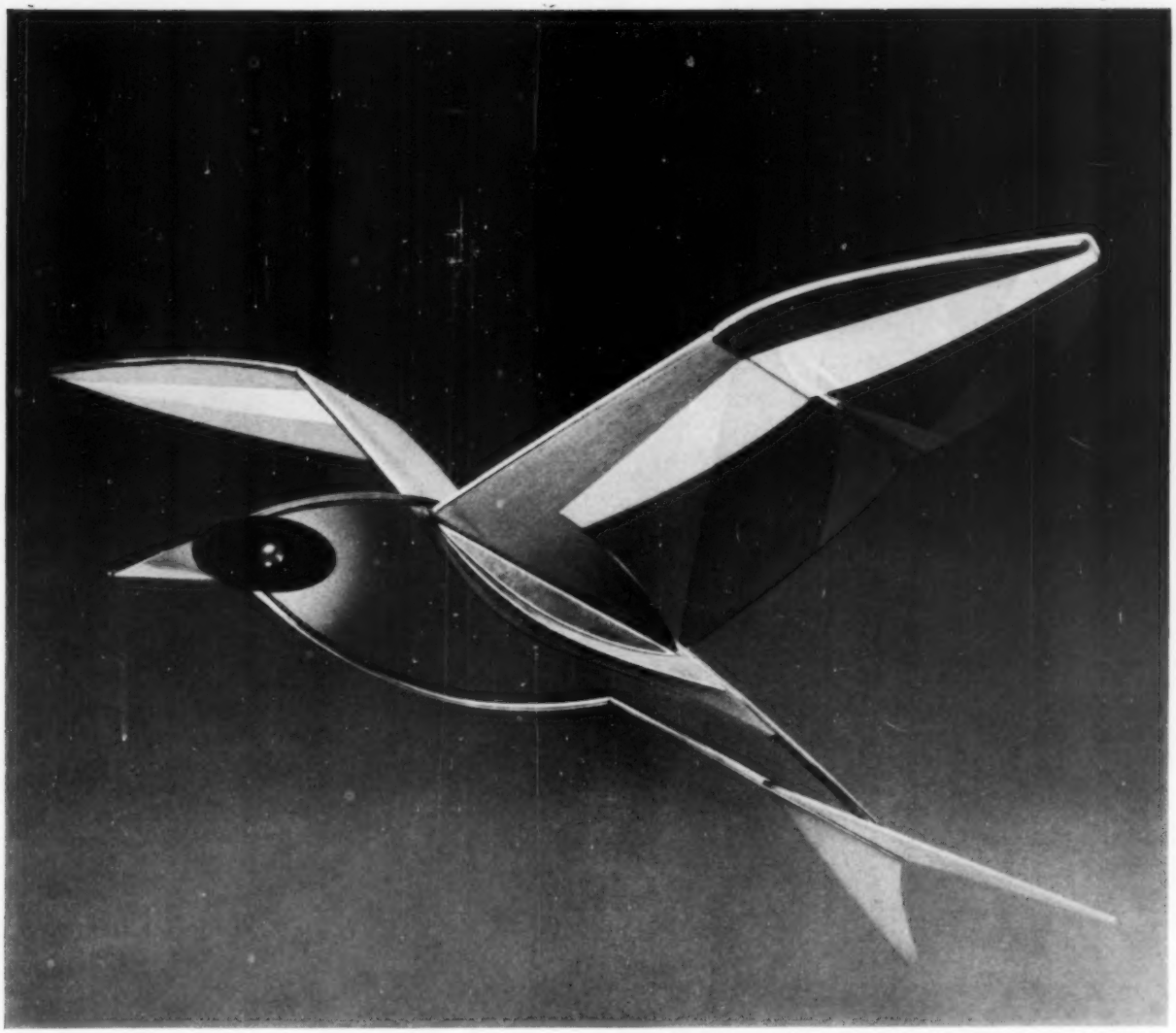
for either high- or low-level operation, is self-contained and mounted directly at point of desired control. Suitable for use with plastic powders or pellets, as well as powdered or granular materials, semi-liquids and liquids. Probe detects presence or absence of material through changes occuring in electrostatic field. Signal is given to control circuit, activating 2-way snap action relay which operates filling or shutoff device. Standard probe length is 6 in., with longer lengths available on request. Requires either 110 or 220 v power supply. **Electronic Controls Div, Flo-Tronics Inc, 712 W Ontario St, Minneapolis.**

**Circle 326 on Reader Service Card**

## "Electric eye" control . . .

has dual light beams. One set of pickups times an inspection and another set monitors it. Device can replace timers and mechanical contacts in monitoring objects moving at random positions and at varying speeds. Light beams may be direct light cutoff or by reflection, or a combination of both. Both beams must concur

continued on page 75



Sculpture created especially for 3M Company by Guy Palazzola

# FEATHER-LIGHT...

## 3M Adhesives help take pounds off today's metalworking products

Reducing dead weight can give a product extra sales advantages . . . make it easier to handle and assemble . . . lower shipping and production costs. The answer: Fabricate with 3M Industrial Adhesives and save weight without sacrificing strength.

In fact, 3M Adhesives often substantially increase the strength of an assembly by distributing stresses evenly over a wide area, making lightweight, high-strength designs possible. And without mechanical fasteners that lower the integrity of the material and cause stress points that tear, fabricators can substitute lighter gauge materials.

For example, 3M Adhesive EC-1357—only one of a complete line of strong, general purpose industrial adhesives—finds wide application in products requiring strength and light weight. It is used in the bonding of metal frames to veneered plywood . . . in honeycomb construction for table tops . . . in sandwich-type wall panels, where it bonds porcelain enameled steel to an expanded glass core.

Backed by a quarter century of research, 3M Technical Service is solving fabrication problems for leading manufacturers in various industries. For an accurate appraisal of how an adhesive can add strength, light weight, production economy, and greater design freedom to your process or product, look first to 3M. Write AC&S Division, 3M Company, Department SBS-31, St. Paul 6, Minnesota.

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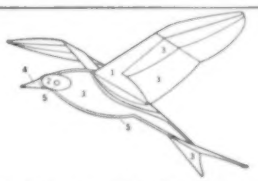

**What do you want to bond to what?**

The Bird is fabricated of these materials and bonded with a variety of 3M Adhesives:

1. Stainless Steel 2. Wood 3. Plastic 4. Glass 5. Brass.

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MINNESOTA MINING AND MANUFACTURING COMPANY

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3M COMPANY

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CIRCLE 72 ON READER SERVICE CARD→

You get **MORE THAN A MOTOR** with General Electric's Form G...for example...

# Versatility Personified

That's an apt description of General Electric's Form G fhp motor if there ever was one. It's the ability to modify, to adapt, to do things differently ... to do them *your* way.

Mount it horizontally, vertically, direct or belt drive ... whatever each of your products requires. You'll find in every case that General Electric's Form G motor "can do."

In addition to versatility, you get these MORE THAN A MOTOR benefits with General Electric Form G motors: *Years-ahead Design Leadership ... Expert Application Aid ... Ease of Assembly ... On-time Delivery ... Fast, Local Service.*

# THESE FORM G MOTOR VERSATILITY FEATURES MEAN GREATER DESIGN FREEDOM FOR YOU

**1. MOUNTING VERSATILITY**—Both solid and resilient cradle bases permit rotation of General Electric Form G motors within base to meet your design and space requirements.

**2. FAST ROTATION CHANGE**—No need to specially order motors to meet your rotation requirements. Just interchange two motor leads; reverse shaft rotation in seconds.

**3. FAST VOLTAGE CHANGE**—Sliding plates on terminal boards allow change from 115 to 230 v operation (or vice versa) in one-fifth the time without confusion or error.

**4. EASY, DIRECT MOUNTING**—Mount Form Gs directly without expensive machining or brackets. Close end shield tolerances allow mounting of motor with simple through-bolts.

**5. ALL-ANGLE OPERATION**—All-angle sleeve bearing and positive oil retention system allow you to mount standard Form G motors in any position. No need for costly specials.

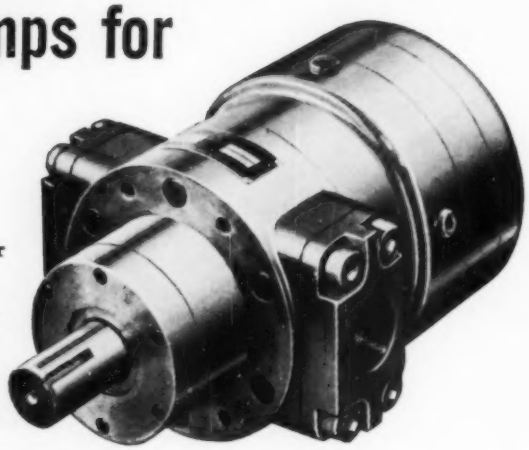
**6. COMPLETE LINE**—Over 850 basic models —and literally thousands of variations—mean there's a standard Form G motor to meet your product's *exact* requirements.

You get these *added values* at no extra cost. So why settle for less? Form G fhp motors are available in NEMA 48 and 56 frames. For more information, call your G-E Sales Engineer or write for bulletin GEA-6424 to Section 721-08, General Electric Co., Schenectady 5, N. Y.

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

# Proper selection of constant volume axial piston hydraulic pumps for systems up to 5000 psi



*By:* Ellis H. Born

*Director of Sales-Engineering*
*Denison Engineering Division*
*American Brake Shoe Co.*
*Columbus, Ohio*

Whether to use a high pressure system or a low pressure system is perhaps the most basic decision the designer faces in developing the proper hydraulic system. This decision involves such factors as efficiency, space requirements and, most important, cost.

## SPACE CONSIDERATIONS

Furnishing fluid horsepower is the function of a hydraulic system. Horsepower yield is determined by multiplying system pressure (psi) times flow rate (gpm) times a constant of 0.000583. Application of this formula reveals that a 5000 psi system develops five times the horsepower of a 1000 psi system at the same rate of flow. Accordingly, the 5000 psi system requires only 20% of the flow rate of a 1000 psi system to produce the same fluid horsepower.

Reduced rate of flow permits designs which incorporate smaller valves, piping, hydraulic cylinders and reservoirs. Since reservoirs are often the largest single fluid component in a system, appreciable space savings can be realized with high pressure systems. If recommended hydraulic practice is followed, reservoir capacity is three times greater than the gpm displacement of the pump. Hence, for the same amount of fluid horsepower, reservoir capacity can be reduced as much as 80% in a high pressure system. The high pressure system not only allows savings in space through use of smaller components and capacities, but reduces the weight and mass of the hydraulic power package as well.

## COST FACTORS

Use of smaller components in high pressure systems not only saves space, but affords worthwhile cost reductions.

Compact system elements cost less and because they are smaller, as well as lighter, assembly is easier and faster. Raw material requirements are also reduced. These advantages permit the over-all hydraulic system design to incorporate less weight and mass. The latter is especially important where portability is concerned.

## SYSTEM EFFICIENCY

In any hydraulic system, a part of the generated fluid horsepower is used to force fluids through the system. Resultant line and pressure decreases are far less significant in high pressure systems. For example, a pressure drop of 50 psi represents a loss of 5% in a 1000 psi system, but only a 1% loss in a 5000 psi system. It follows that high pressure systems have an inherent efficiency advantage over low pressure systems.

The ability to provide sustained efficient power for a high pressure system is best fulfilled by a precision-built axial piston pump because of its low slippage rate and operating characteristics.

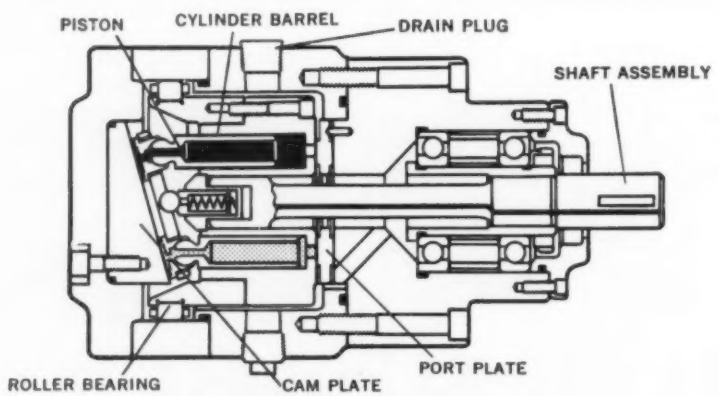
All internal forces created by hydraulic pressure against the moving parts are counteracted by the use of hydraulic balancing.

Using the principle of hydrostatic balancing eliminates the need for expensive and often cumbersome thrust bearings in the pump. This design minimizes pump size and allows a more compact pump or fluid motor package.

Other advantages are gained through hydrostatically balancing pistons and the cylinder barrel. For example, excessive loading of piston shoes against the cam plate is avoided. In addition, excessive loading of the cylinder barrel against the port plate is prevented, virtually eliminating wear caused by sliding action.

Life expectancy of internal axial piston pump parts is almost infinite since constant lubrication is supplied by system fluid.

Data and specifications on 5000 psi pumps, motors and controls are available from your Denison representative—located in principal cities—to assist you in developing hydraulic systems for maximum efficiency and economy.




DETAILS OF CONSTRUCTION

## NEW CATALOG FOR DESIGNERS AND ENGINEERS

Write for your copy of Bulletin 220—"Hydraulic Power to 5000 psi" and Bulletin 203—"Axial Piston Pumps". Includes complete specifications, operating data and applications for Denison's full line of hydraulic pumps, motors and controls.

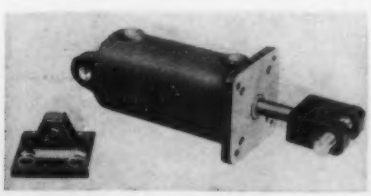
**DENISON ENGINEERING DIVISION**
**American Brake Shoe Company**
1194 Dublin Road • Columbus 16, Ohio

in order to pass an acceptable unit. If a reject is detected, relay signal can be used to actuate an audible, visual alarm or a reject mechanism. **Photomation Inc, 96 S Washington Ave, Bergenfield, NJ.**

**Circle 327 on Reader Service Card**

**Hydraulic pumping units . . .** offer pressures up to 2500 psi and flow rates from 0.6 to 4.2 gpm. Suitable for lift trucks, small clamping mechanisms, gate valve operations, etc. Base of unit forms oil reservoir. Motor, pump, filler and breather assembly, and pressure and return connection are mounted as an assembly on reservoir cover (aluminum die casting base plate). By removing four bolts, assembly can be removed for inspection or cleaning. **Racine Hydraulics & Machinery Inc, 2000 Albert St, Racine, Wis.**

**Circle 328 on Reader Service Card**



**Single-acting cylinder . . .** uses only slightly more than half the air volume required by double-acting cylinders of same size and can serve as double-acting unit when needed. Has spring-return, which allows use of 3-way instead of 4-way valve. With face or clevis mounts, cylinder is available in 2½- 3-, 4- and 5-in. bore sizes, with 1-, 2- or 3-in. strokes. **Fluid Dynamics Div, Mead Specialties Co, 4114 N Knox Ave, Chicago 41.**

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continued on page 78

From Blueprint
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CONSOLIDATED
gets it
done!
At Consolidated, we take the designer's concept and turn it into exciting, satisfying reality.
Consolidated has always handled the tough jobs—the special jobs that "couldn't be made from plastics." And today at Consolidated we're still pioneering—still finding new, better ways to work with newer, better materials.
Most of America's blue chip companies are on the honor roll of Consolidated customers. How About You?
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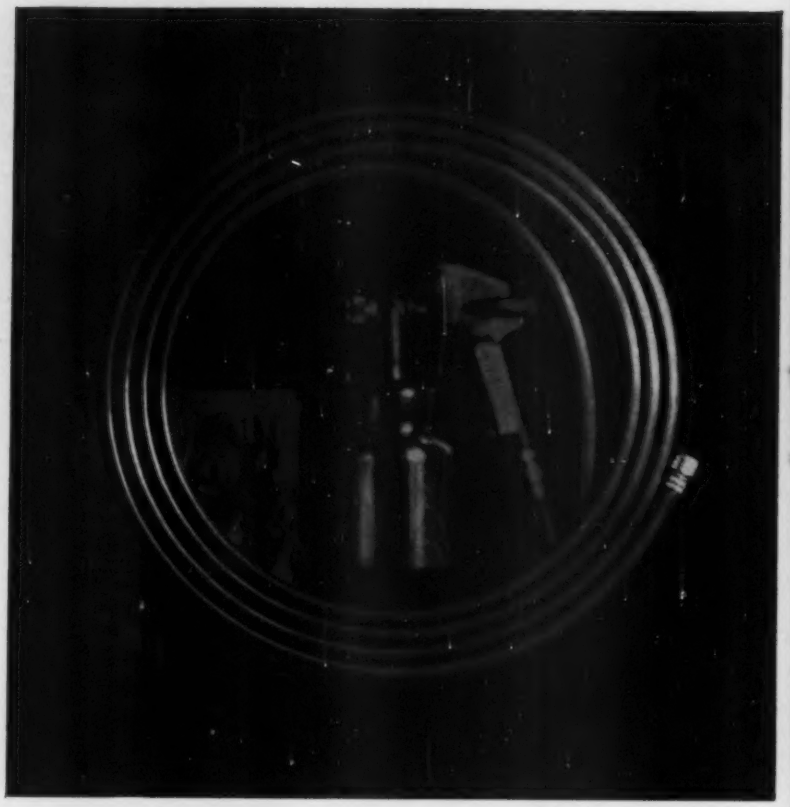
Send for your free copy of our new 20-page Facilities Report

# WHY POLYSULFIDE CRUDES

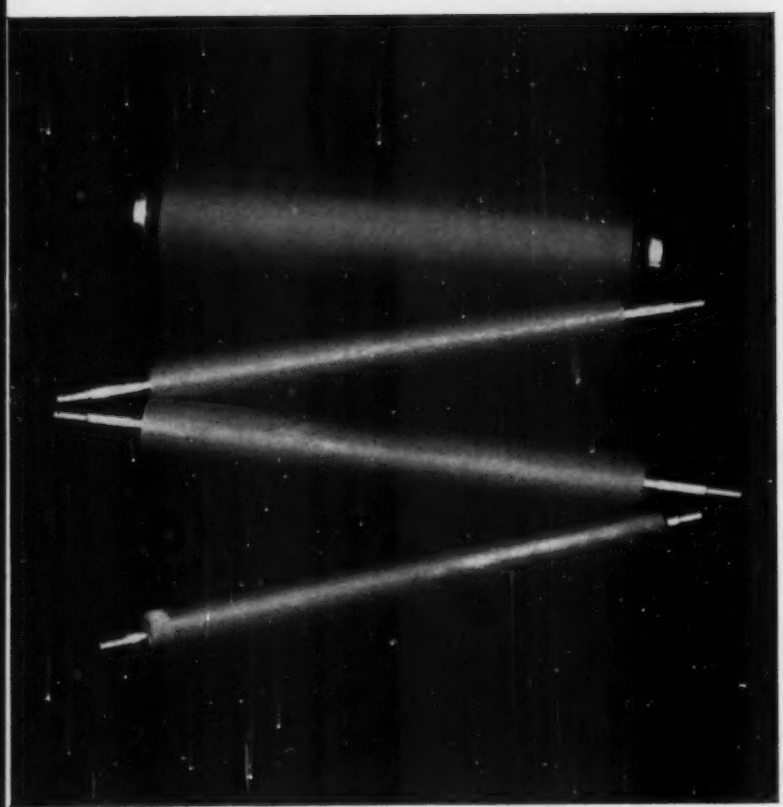
**HIGH SOLVENT RESISTANCE.** Industry has found no other elastomers perform so well so long under exposure to oils, aromatic fuels, chemicals, solvents and other degrading liquids as THIOKOL polysulfide crudes. Top name manufacturers of paint spray equipment, for example, have made polysulfide rubber the traditional choice for lining hose. As a carrier of paint, solvent, thinners, THIOKOL polysulfide rubber provides trouble-free service years on end.



**LOW TEMPERATURE FLEXIBILITY.** Though the mercury drops far below zero, polysulfide crudes stand up—without plasticizers. No brittleness. No cracking. No loss of serviceability. In demanding applications such as gaskets and O-rings in aircraft fuel systems, THIOKOL polysulfide rubber keeps its resiliency through the low temperatures of high altitudes. Rubber components, hose, sheeting can be fabricated for service at temperatures to minus 65 deg. F.

# ARE PICKED FOR THE BIG JOB

**IMPERMEABILITY TO GASES.** From sheets of polysulfide rubber or fabrics coated with it, manufacturers of gas meter and regulator diaphragms are producing the most reliable measuring components ever. THIOKOL polysulfide crudes maintain full integrity though constantly exposed to degrading gases, sunlight, ozone, vapors and to wear of diaphragmatic action.



**LONG LIFE.** Widening use on printing and coating rollers constantly subjected to solvents, thinners and physical stress underscores ability of THIOKOL polysulfide crudes to deliver long service life under severe conditions.

Thiokol offers comprehensive technical literature detailing properties and performance characteristics of polysulfide crudes. Copies of this helpful material will be mailed to you on request. Write on your letterhead, or use handy coupon.

Thiokol®
CHEMICAL CORPORATION

**THIOKOL CHEMICAL CORPORATION**
**780 N. Clinton Ave., Trenton 7, N.J.**
*In Canada: Naugatuck Chemicals Division, Dominion Rubber Company, Elmira, Ontario*

Gentlemen: Please send further information about following properties of polysulfide crudes: ☐ High solvent resistance ☐ Impermeability to gases ☐ Low temperature flexibility

Name_____
Firm_____
Address_____
City_____ State_____

## Tread-lock brake . . .

for caster wheels, has permanently bonded composition brake shoe located directly beneath brake spring. Brake banding technique is said to provide more positive braking on wheel face (preventing wear on wheel mechanisms) and to eliminate wheel distortion. Brake shoe also allows firm stopping on harder tread wheel surfaces such as steel, plastic and hard rubber. To increase brake's over-all strength, embossed pedal made of 0-090 steel, extends to caster's horizontal leg. **Colson Corp, 7 S Dearborn St, Chicago 3.**

**Circle 330 on Reader Service Card**

## Wire rope . . .

is made of seven strands helically laid around a core. Said to have 16⅔% more wearing surface than 6-strand rope and flexibility of 8-strand rope. Available in ½ to 1¼-in. dia, ranging in strength from 13.1 to 64.2 tons. **MacWhyte Wire Rope Co, 2900 14th Ave, Kenosha, Wis.**

**Circle 331 on Reader Service Card**

## Stud-mounted rectifiers . . .

handle up to 40 amp at 302 F in half-wave circuits and up to 60 amp in full-wave circuits. Peak inverse voltage capability is from 50 to 800 v. Have double-diffused, silicon junction construction. From stock. **Trans-Sil Corp, 55 Honeck St, Englewood, NJ.**

**Circle 332 on Reader Service Card**

## Flat-armature torque motors . . .

have pole pieces, magnets, coils and armatures contained and affixed to non-magnetic stainless steel frames. Eliminate problem of magneto or pole pieces shifting position or breaking away from assembly in either shock or vibration. Four models in series are electromechanical transducers which transform min of electrical power into max linear mechanical displacement and force proportional to input control current. Also suitable in high response electrohydraulic, electropneumatic and hot-gas servosystems. All models have high performance-to-weight ratio (weigh from 2.8 to 18.5 oz), and operate continuously at temperatures of 450 F. Stroke ranges from ±0.006 to ±0.015 in.; output radius, 0.650 to 0.906; midposition force, 2.5 to 13 lb; hysteresis, 2%; resonent frequency, 940 to 400 cps; and max power requirement, 1.6 to 5.2 w. **Servotronics Inc, 190 Gruner Rd, Buffalo 25, NY.**

**Circle 333 on Reader Service Card**

## Battery protector cap . . .

traps gases and by catalytic action reconverts hydrogen and oxygen into water which drips back into cell to maintain electrolyte level above plate tops indefinitely. Warns of overcharge by turning hot to touch (normally warm to touch). **Hydro-Catylator Corp, 237 Sunrise Hgwy, Rockville Centre, NY.**

**Circle 334 on Reader Service Card**

## Power rheostat . . .

with push-pull action, can be used at full wattage rating with as little as 25% of its winding in use. Available with standard or tapered windings in 100, 200 and 300-w sizes. Has lightweight metal housing for improved heat dissipation and distribution and is adaptable to any linkage for either manual or automatic operation. **Milwaukee Resistor Co, 700 W Virginia St, Milwaukee 4.**

**Circle 335 on Reader Service Card**

## Pressure gages . . .

are said to be accurate within 1% of dial reading. Available with silver-brazed copper alloy bourdon tube and bronze-bushed movement for pressure media not corrosive to brass or with stainless steel bourdon tube and stainless and monel movement for entirely corrosion-resistant service. All models are 2½-in. dial size with ¼-in. NPT male bottom connections. Ranges are 15, 30, 60, 100, 160, 200, 300, 600, 1000 lb and 30-in. vacuum. **Marsh Instrument Co, Div. of Colorado Oil & Gas Corp, Skokie, Ill.**

**Circle 336 on Reader Service Card**

## Small-appliance thermostat . . .

measuring ⅜ in. round and ¼ in. thick, has open or closed ½-in. bimetal snap-acting disk. Can be used as is or enclosed in various metal housings. Handles currents to 20 amp, voltage to 240 v ac. **Therm-O-Stats Inc, PO Box 303, Chartley, Mass.**

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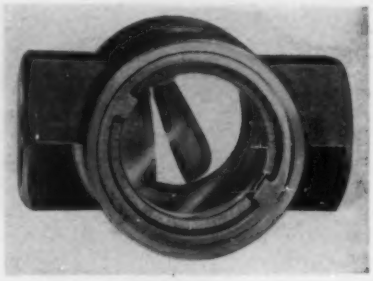

## Sight flow indicator . . .

for viewing inside pipelines, has double sight glasses, allowing clear observation of fluid even under poor lighting conditions. Uses machined recesses and retaining rings for even seating of sight glass gaskets to prevent leakage. **Schutte & Koerting Co, Dept M-V, Cornwells Heights, Bucks County, Penna.**

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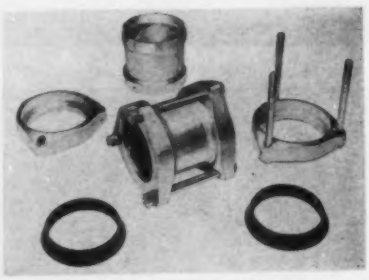


## Pneumatic line coupling . . .

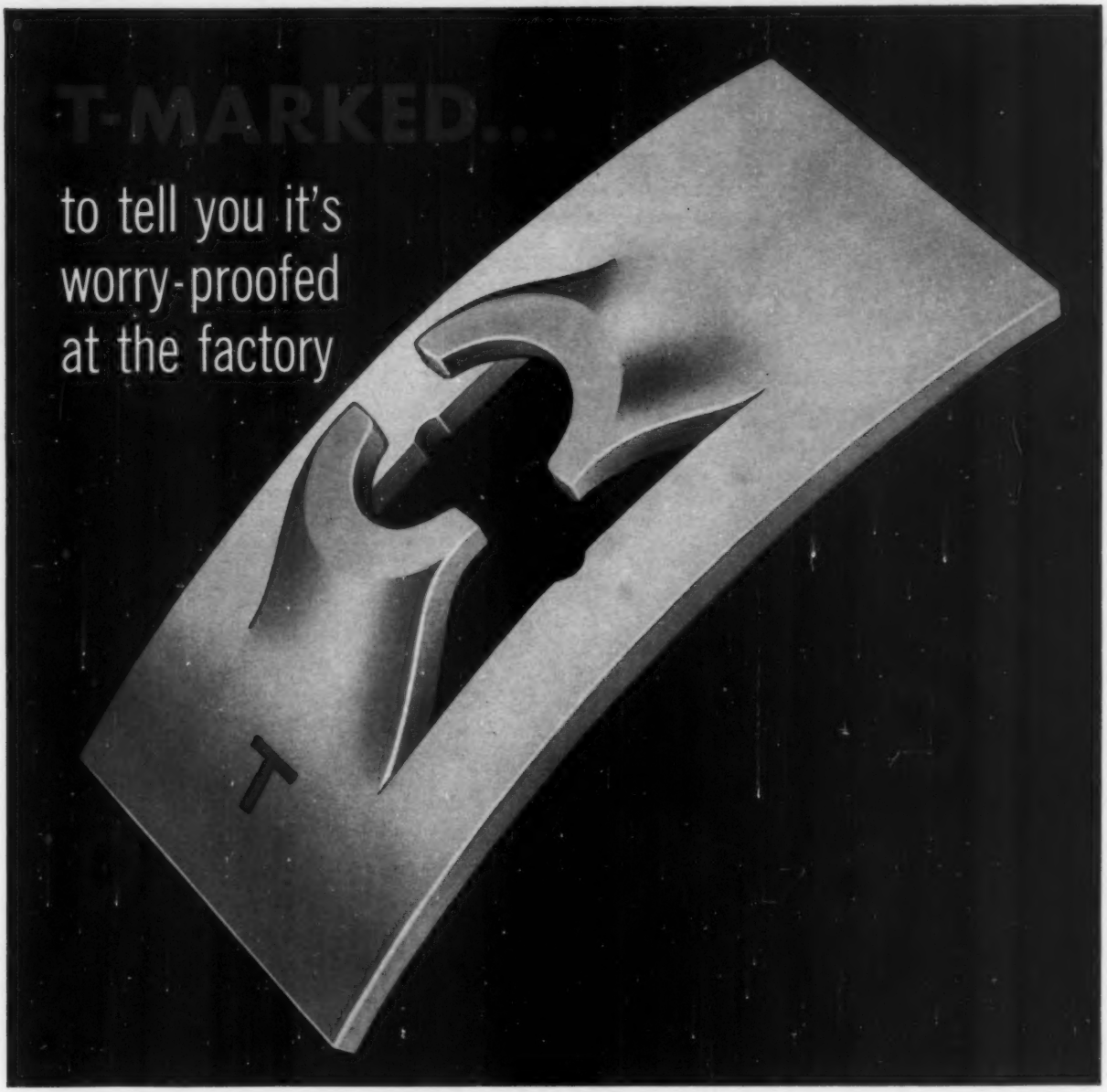
is suitable for joining sight glass sections with max protection against stresses that crack or break the glass. Extra large neoprene gaskets and special construction permit positive seal and gripping action even when tubing is appreciably out of round. Also makes connections on arc of an elbow without requiring straight sections. Made of cast aluminum and mounted with three cadmium plated take-up bolts, unit provides strong safe seal under any pressure up to 100 psig. Sizes range from 1½ to 4 in. dia. **Fluidizer Div, Daffin Corp, Hopkins, Minn.**

**Circle 339 on Reader Service Card**

## Electronic rack cabinet . . .

made by standard tools and dies, has adjustable ventilating system for cooling electrical equipment. Duct outlets can be positioned vertically at any location,

continued on page 82




Other spring fasteners may look like Tinnerman SPEED NUTS. But only the *T-marked* ones really are SPEED NUTS . . . really are "Tinnermans". . . made to highest quality and precision standards to assure worry-proof performance on your assembly.

Here's what the exclusive Tinnerman T-mark means to fastener users:

Over thirty-five years of Tinnerman experience as the originator and largest producer of spring-steel fasteners...the leader in solving your fastening problems,

Outstanding fastener design and production experience that assures you the best possible design of SPEED NUT, whether it is a special SPEED NUT or one of the 10,000 SPEED NUT brand fasteners presently available,

Stringent control of SPEED NUT quality from coil strip to you, including die design, production, heat treatment and finishing.

Be sure you specify "Tinnerman T-marked SPEED NUTS" that give you better fastening, that cut parts and assembly costs, that never let you or your customer down. *Tinnerman Products, Inc., Dept. 12, Box 6688, Cleveland 1, Ohio.*

**TINNERMAN**
*Speed Nuts®*
Look for the Tinnerman "T"

## The better it runs—the better you live!

Volume goes up—prices come down. Cheaper by the dozen, cheaper still by the million. That's because advertising is on the job, building mass markets. Then increased demand makes more jobs—puts more money into circulation for bigger buying power. It's the American cycle of productivity and plenty, and there's no limit to what it can do for all of us.

***Let's Keep Rolling Ahead***

# Uniformity and long cycle life earn preference for **Flexonics** bellows with leading control manufacturers

For measurement and control of process variables, the country's leading instrument manufacturers are specifying Flexonics Bellows. Uniformity of effective area and spring rate . . . adaptability to a wide variety of fittings . . . a broad range of sizes and materials . . . and proved long cycle life—are only a few of the many reasons for this strong preference.

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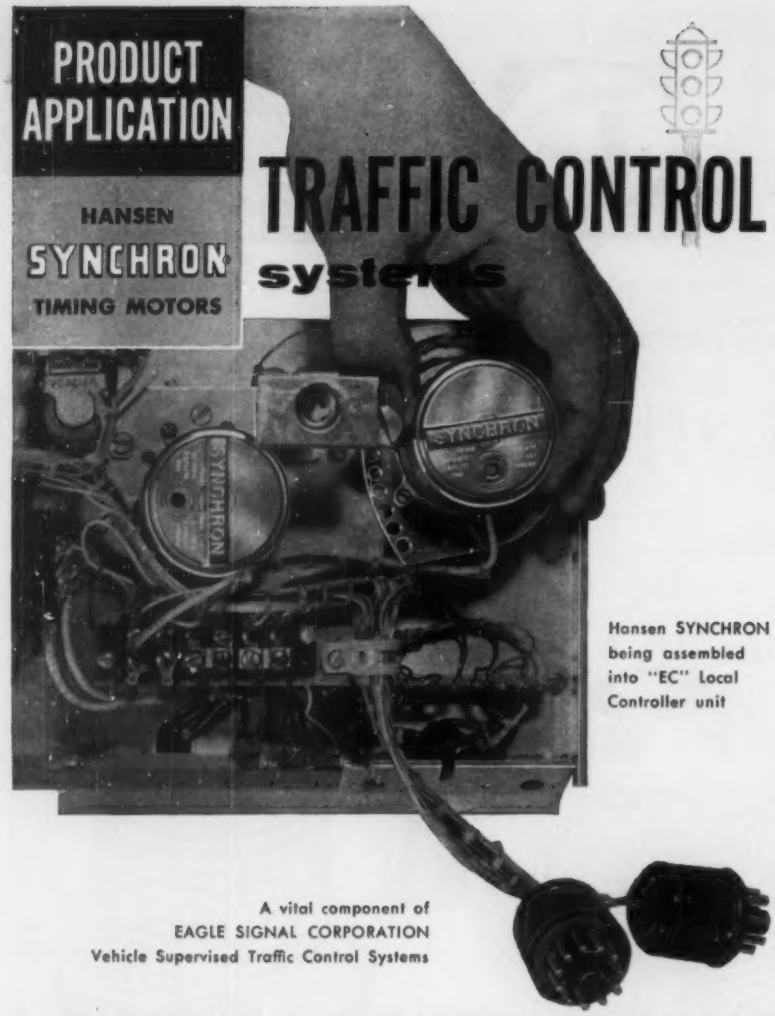
PRODUCT APPLICATION

HANSEN SYNCHRON TIMING MOTORS

# TRAFFIC CONTROL systems




Hansen SYNCHRON being assembled into "EC" Local Controller unit

A vital component of EAGLE SIGNAL CORPORATION Vehicle Supervised Traffic Control Systems

**EAGLE SIGNAL CORPORATION** uses Hansen SYNCHRON motors for synchronous power to govern signal timing operations in "EC" Traffic Control Systems. Hansen SYNCHRON motors regulate amber and pedestrian clearing intervals — and all other intervals which remain *constant* regardless of cycle length . . . and also govern the 4 independent traffic splits (time division for vehicular traffic) — as well as any interval which is *variable* according to cycle length. The Hansen SYNCHRON, regulating constant intervals, operates on 60-cycle power supply . . . the one governing variable intervals responds to variable frequency from the master control unit.

**HANSEN SYNCHRON TIMING MOTORS** were chosen by Eagle Signal after careful testing of several makes of synchronous motors. Due to the size of some timing devices and control units, a small motor with good performance characteristics was needed to fit the space limitations. After extensive tests, Hansen SYNCHRON motors were specified for: (1) high-quality performance under test; (2) lower cost; (3) long-life operation as an integral part of traffic control units. Since adoption, Eagle Signal has never experienced an assembly slowdown or stoppage due to failure on service or delivery of Hansen SYNCHRON Timing Motors.

**SEND TODAY** for informative folder containing specifications and technical data on all Hansen SYNCHRON motors and clock movements.

HANSEN MANUFACTURING COMPANY, INC. PRINCETON, INDIANA

**HANSEN REPRESENTATIVES:**
**THE FROMM COMPANY**
5150 W. Madison, Chicago, Illinois
**H. C. JOHNSON AGENCIES, INC.**
Rochester, N. Y. — Buffalo, N. Y. — Syracuse, N. Y.
Binghamton, N. Y. — Schenectady, N. Y.
**ELECTRIC MOTOR ENGINEERING, INC.**
Los Angeles, Calif. — (OLive 1-3220)
Oakland, California
**WINSLOW ELECTRIC CO.**
New York, N.Y. — Essex, Conn. (SOuth 7-8229)
Philadelphia, Penn. Cleveland, Ohio

Sweet's Product Design File




with adjustable scoops permitting regulation and balancing of air discharge. Suitable for modular unit expansion, cabinet has hinged rear door for easy access to internal components. Made of heavy gage, cold-rolled steel or aluminum and measures 24 x 24 x 77 in. **Falstrom Co, 185 Falstrom Ct, Passaic, NJ.**

**Circle 340 on Reader Service Card**

## Silicon controlled rectifiers . . .

switch up to 5 amp of current over peak reverse voltage range from 20 to 400 v. Enable rapid firing (1 to 5 usec) with min of current (2 to 5 ma typical) on such applications as static inverters, dc power regulators, dc motor controls, temperature and lighting controls, dynamic braking, etc. Similar to gas thyratron, but said to provide faster triggering and recovery, lower forward voltage drop and high temperature operation. From stock at $5 to $55 each in quantities of 1 to 99. **International Rectifier Corp, 1521 E Grand Ave, El Segundo, Calif.**

**Circle 341 on Reader Service Card**

## Force gage . . .

used to measure ounces and grams of snap action switch characteristics and application force requirements, is available for $1 to switch engineers who supply name, title, company name and estimated yearly switch usage. Valued at $8.50, gage measures approx 6 in. **Cherry Electrical Products Corp, 1650 W Deerfield Rd, Highland Park, Ill.**

**Circle 342 on Reader Service Card**

## Bamboo slide rule . . .

has extended range of log log scales for solving problems involving fractional or non-integral powers and roots of integral or non-integral quantities. Specially treated laminated bamboo neither contracts nor expands with changes in temperature or climatic conditions. Facing is of ivory white plastic for top readibility. Comes in three 10-in. models, each designed for mechanical engineer, advanced electronics engineer and scientist. Also available is a 5-in. pocket model for advanced electronics engineer at $15.50 to $26.50. **Alvin & Co Inc, 611 Palisado Ave, Windsor, Conn.**

**Circle 343 on Reader Service Card**

**Smallest, Fiercest** of mammals, the mole-like, fractional-ounce shrew consumes several times its own weight of insects daily — may even kill and eat mice many times its own size. In fact, this little lightweight is so formidable that its name has been adapted to classify certain human traits; for example, "shrewish" and "shrewd".

**Ideal For Missiles** and other space-saving applications, this tiny rotary actuator meets military specifications for high speed torque. Measuring 2⅞" x 2¼" x 1⅝" it is 50% smaller, weighs 50% less, than its predecessor. MPB bearings, first selected as shaft supports for special models, proved so satisfactory that they are now specified on standard models.

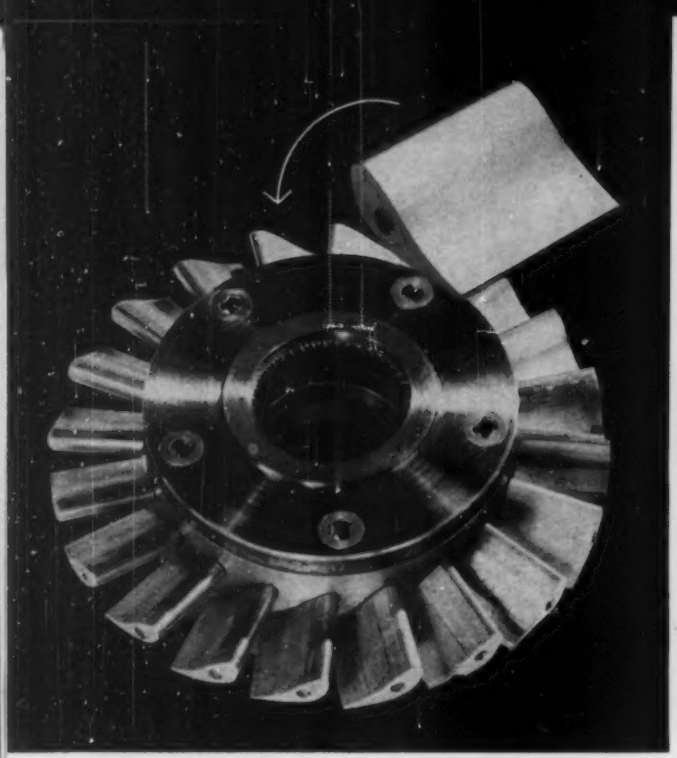
**Man With Miracles.** Like all MPB Sales Engineers, Ray Sparks has had considerable experience in helping designers choose exactly the right MPB bearings for best results in miniaturization or in instrumentation — or in both. He is well qualified to bring expert advice to your own product development and solution of problems in these fields.

*Miracles in Instrumentation*

ACTUAL SIZE OF THE MPB BEARINGS IN ACTUATOR SHOWN ABOVE

**Specialized customer service** is one of the most valued features of MPB engineering. In addition to developing new precision bearings for miniature and precision applications, the news-making MPB Technical Center at Keene provides customers with constant teamwork in the development of modern mechanisms. For details about MPB service—and for a catalog on MPB bearings, the world's largest line — write to **Miniature Precision Bearings, Inc.**, 93 Precision Park, Keene, N.H.

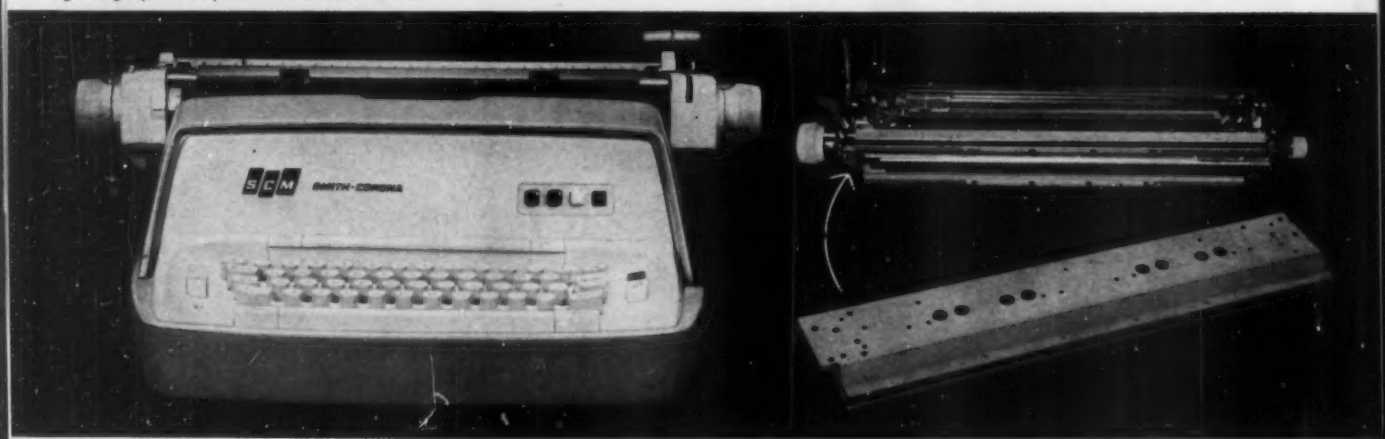
MPB *Helps you perform miracles in instrumentation*



Automotive transmission stator blade

Lightweight precision part for Smith-Corona "400"

Printer's furniture, The Challenge Machinery Company




# ELIMINATE MACHINING, CUT PRODUCTION COSTS WITH MAGNESIUM PRECISION EXTRUSIONS

These close-tolerance parts were produced with no machining costs! They're Dow precision magnesium extrusions which require only end trimming or cutting to length before use . . . and where transverse holes are needed, drilling and tapping. Dow precision magnesium extrusions help manufacturers cut production costs, while providing tolerances as close as ± .001 inch on critical cross-sectional dimensions, dimensional stability and light weight. There is no machining on the typical parts above . . . component for the ultra-modern Smith-Corona "400" Office Electric Typewriter; The Challenge Machinery Company's printer's furniture; and automotive transmission stator blade. Precision magnesium extrusions can be produced with sharp V's, thin notches, and accurate serrations. Complex parts can be given a consistent precision fit. For information, write to THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1104DZ3-27.

DOW

**THE DOW METAL PRODUCTS COMPANY**

*Division of The Dow Chemical Company*

CIRCLE 84 ON READER SERVICE CARD

DOW

## NEW DOW MAGNESIUM ALLOY ZE10A

high welded joint strength and no stress relief!

New Dow magnesium alloy ZE10A needs no post-welding stress relief. This strong sheet alloy is ideal for fabricating containers, vehicle bodies and other structures . . . and for field repair operations where stress relief can be a real problem.

ZE10A provides very high welded joint strength, important in butt welding of plates. The result—strong, stiff weldments of very light weight . . . with greater capacity, pound-for-pound, than structures made from any other metal!

To weld ZE10A sheet to extrusions, use Dow extrusion alloy ZK21A. No stress relief required. For further information and data, write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1152DZ3-27.

ZE10A makes light, strong containers, like this Tote Bin, built by Tote Systems, Inc., Beatrice, Neb., a subsidiary of Hoover Ball and Bearing Company.

DOW

THE DOW METAL PRODUCTS COMPANY
*Division of The Dow Chemical Company*
*Midland, Michigan*

# DESIGN LITERATURE

### Early Motor-cars

***GEORGE A OLIVER. Stephen Green Press, 120 Main St, Brattleboro, Vt. 14 x 19, App 55 pp. Limited edition of 750 copies, $20.***

When and why did automotive styling—which now seems to dominate the industry—become a part of auto design? This book describes and illustrates 12 cars which were the most significant models built between 1904 and 1915. This period was one of extensive engineering improvements and just making the car go was no longer the basic problem. A reasonable degree of reliability had been achieved and designers were able to apply themselves to improving braking, steering, maintenance and appearance. This period saw the birth of styling and cars began to develop characteristic shapes. The early attempts were severe as the breakaway from carriage coach work became more pronounced. Though it lacked elegance, early styling was usually practical and frequently handsome. This is in contrast to the indiscriminate use of sheetmetal and glass that is frequently referred to as styling today.

The 12 full-color plates have been prepared with precise attention to technical detail by the author-illustrator. The text accompanying each illustration provides pertinent technical data to substantiate the author's selection of these cars as the significant models of an important automotive era. The color plates are magnificent and would undoubtedly cost more than the price of the book if purchased separately. The book will prove invaluable to anyone in the automotive design field and will be appreciated by anyone who has even a passing interest in the auto car.—JJK

### Heat Conduction in Distributed System

***J R NORTON, L D ZIRKLE. Oklahoma State University, Stillwater, Okla. 8½ x 10¾, 100 pp. $2.50.***

When heat input to a part is a periodically varying function, rigorous mathematical treatment is difficult. This book discusses several alternative methods, including Fourier series and the separation of variables. Author introduces a single solution that is applicable to all systems in which the driving function is periodic. He applies the reflection type of analysis usually associated with electrical transmission lines. Included are data on thermal conduction tests on finite simple and composite rods.

### Electronic Equipment Reliability

***G W A DUMMER & N GRIFFIN. John Wiley & Sons Inc, 440 Park Ave South NYC. 8¾ x 5½, 274 pp. $7.50.***

The author draws from years of experience to summarize all types of failures and show special limitations of all types of parts, coatings, devices and circuits. Much of the book deals with circuit design to reduce total number of parts that can fail. Typical chapter headings are: Faults in Electronic Equipment, Environmental Conditions, Constructional Techniques, and Reliability Prediction and Calculation.

### Other Books of Interest

#### ASME Metallizing Symbols

**ASA Y32.12-1960. American Society of Mechanical Engineers, 29 W 39th St, NY 18. 6 x 9, 7 pp. $1.**

#### Platinum and Allied Metals Bibliography

**Office of Technical Services, US Dept of Commerce, Washington 25, DC. 8 x 10½, 8 pp. 10¢.**

***Lists reports in OTS' monthly abstract journals from 1941 through July 1960.***

# ABSTRACTS FROM THE LITERATURE

### Battery Systems

A review of the battery field and an evaluation of the status of the lead battery, as compared to other competitive systems.

***"The Choice of Battery Systems," by C. G. Grimes and W. S. Herbert, The Electric Storage Battery Co. Paper No. 269D, SAE, 485 Lexington Ave, New York 17.***

### Hardness of Polymeric Materials

The hardness of a polymeric material is usually evaluated by observing the distance of indentation and recovery that occurs when a penetrator is forced into a flat surface and then released. To compare materials, the results of such hardness measurements

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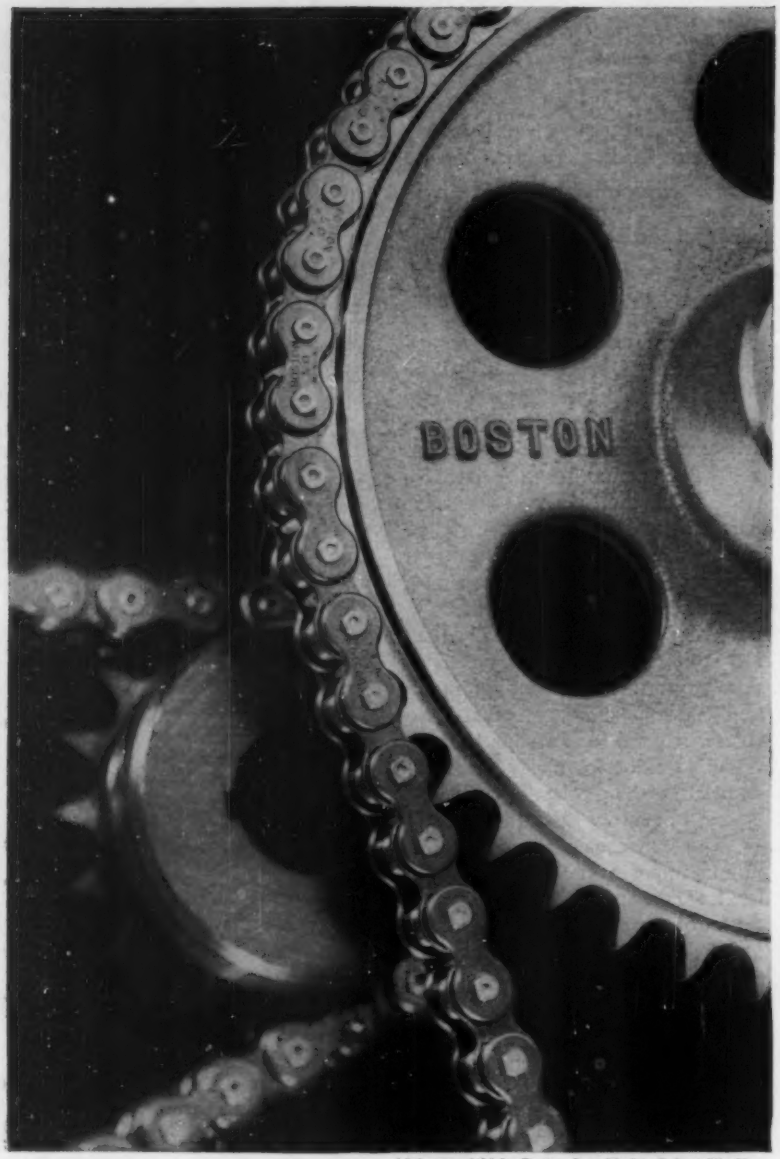
# BOSTON Gear® QUALITY

## sprockets and chain

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Off the shelf - at factory prices.
For any chain drive 1/4" to 2" pitch -
Roller, Block, Ladder. See Catalog 57.
Design around the quality leader.

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are then recorded according to the prescribed hardness scales. This paper shows how the results of hardness tests can be interpreted in terms of the stress-strain behavior of the material.

*"Hardness of Polymeric Materials," by Eric Baer, R. E. Maier, and R. N. Peterson, E I du Pont de Nemours and Co. Presented at the 17th Annual Technical Conference, SPE, 65 Prospect St, Stamford, Conn.*

### Fire-resistant Hydraulic Fluids

This is a report of a survey of industry opinion of fluid properties, costs, toxicity, conversion problems, insurors attitudes.

*"What Industry Thinks of Fire-resistant Fluids," S S Livers. Control Engineering, Feb '61, 330 W 42nd St, New York 36.*

### Shear Spinning

Uniaxial and biaxial mechanical and metallurgical properties of ultra-high-strength steels are evaluated, based on tests of shear spun cylindrical sections of AMS-M255 and Ladish D6a.

*"Metallurgical Aspects of Shear Spinning Ultra-high-strength Steels," P P Crimmins, Aerojet-General Corp. American Rocket Society paper 1601-16. American Rocket Society, 500 Fifth Ave, New York 36.*

## CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

RETAINING RINGS—Catalogs 30 and 31, 4 pp. each. Former covers prestacked internal rings; latter, external rings—both types in sizes from 0.250 to 1.375 in. Tables show housing dia; ring and groove dimensions; ring clearance; and thrust strength in pounds. Price lists included. Industrial Retaining Ring Co, 57 Cordier St, Irvington 11, NJ.

**Circle 350 on Reader Service Card**

GLASS POLYESTERS—Brochure B8216, 8 pp. Presents physical and electrical properties of 10 grades of glass-mat laminates and three grades of glass molding compounds with low, medium and high impact qualities. Westinghouse Electric Corp, Micarta Div, Hampton, SC.

**Circle 351 on Reader Service Card**

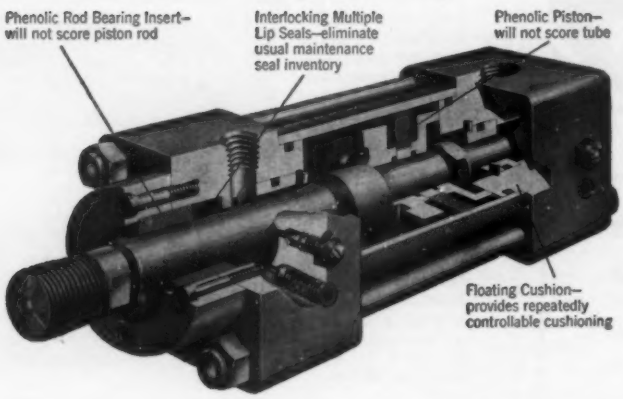
WELDING ALLOYS—Wall chart, 19½ x 25½ in. Indexes line of welding, brazing and soldering alloys and fluxes under common base metals. Describes each joining alloy with recommended preheats,

continued on page 89

# Fluid Circuitry News from Westinghouse

## Industrial Product Division expands line

The Petch line of high quality air and hydraulic cylinders is now part of the line of Westinghouse Fluid Circuitry components. This acquisition makes it possible for us to offer industry the *most complete line* of air and hydraulic components for control systems to automate industrial production operations.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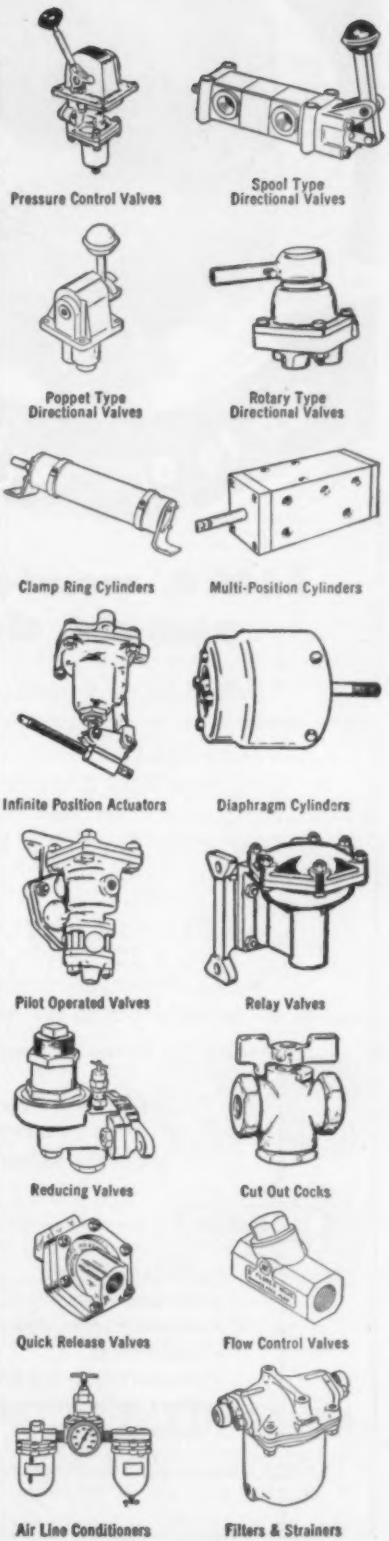


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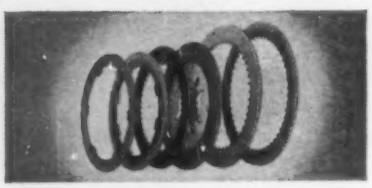

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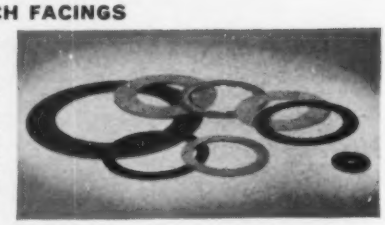

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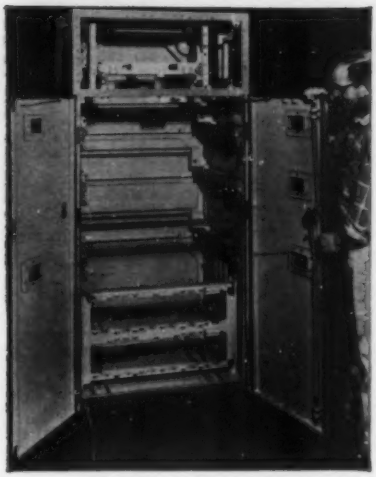

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amperage or working temperature, and tensile or shear strengths. Featured are correct joining alloys for major weldable aluminum alloys. All-State Welding Alloys Co Inc, 249-55 Ferris Ave, White Plains, NY.

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FASTENERS—Bulletin 2449, 8 pp. Tables, supplemented by sketches identifying types of fasteners, spell out materials, threads and size ranges of socket-screw products, pressure plugs, locknuts, spring pins, dowel pins and steel collars. Photos and cutaways show design features and applications. Standard Pressed Steel Co, Box 545, Jenkintown, Penna.

**Circle 353 on Reader Service Card**

LIMIT SWITCHES—Bulletin GEA-7312, 12 pp. Discusses typical applications of lever, leverless and rotating-cam and limit switches, as well as tripping forces for activating each switch. Each model is illustrated by cutaway and dimensional drawing, while installation do's and don'ts are sketched. General Electric Co, Schenectady 5, NY.

**Circle 354 on Reader Service Card**

MULTISPEED MOTORS—Bulletin 1300, 4 pp. Covers construction features and ratings of variable-torque, constant-torque and constant-hp units—both polyphase and single phase. Curves show speed-torque characteristics. Century Electric Co, 18th & Pine Sts, St Louis 3.

**Circle 355 on Reader Service Card**

SILICONE-INSULATED CABLE—Bulletin, 4 pp. Outlines key properties of silicone-rubber insulation and presents curves showing insulation behavior of conductors under direct flame. Tables give single and multiconductor cable sizes, diameters over insulation and dielectric strengths. Boston Insulated Wire & Cable Co, 63 Bay St, Boston 25.

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continued on page 91

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► **The development of three low cost elements ready to build into the housing of any mechanism requiring a pumping function eliminates the purchase of complete pumps.**

Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

► Mounting pads, couplings, connectors and accessory drives are done away with by this progress in design. Consisting of an inner and outer Gerotor and an eccentric locator-ring, the unit becomes a complete pump by simply through-boring the casting or frame of the mechanism to accommodate the locator ring O.D. and to provide porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft.

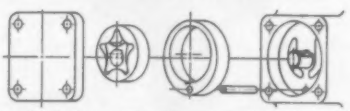

Fig. 2. Nichols integral pump-package is easily installed integrally into most mechanisms.

► **The matched elements are as easily built-in as a simple anti-friction bearing would be. Further, the Gerotor pump is extremely flexible in its configuration and readily adapts to a wide variety of mechanism geometries. It will handle a variety of fluids at rates up to 100 gpm and pressures up to 1,000 psi.**

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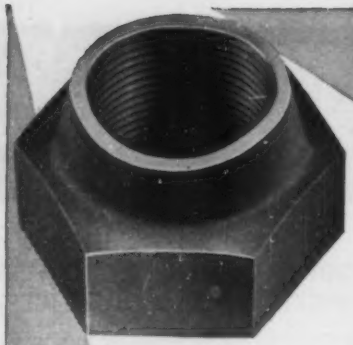

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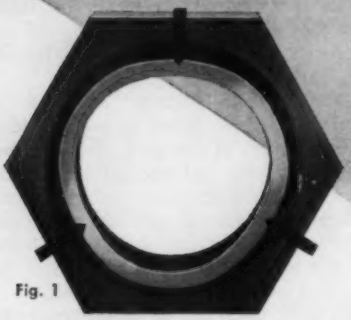

Fig. 1

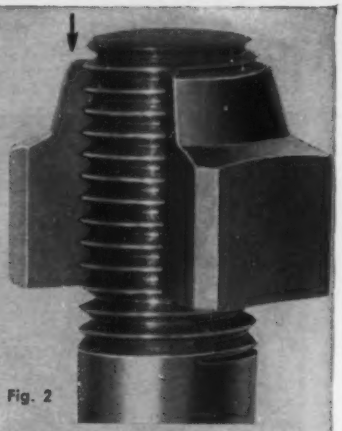

Fig. 2

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**DESIGN LITERATURE**.....continued

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**SELF-LOCKING FASTENERS**—Catalog 960, 64 pp. Contains specifications and dimensional drawings of lightweight hex, anchor and clinch-type nuts, some for electronic and avionic end uses. Outlines and illustrates installation of clinch types. Elastic Stop Nut Corp of America, 2330 Vauxhall Rd, Union, NJ.

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**STRUCTURAL MATERIALS**—Booklet, 8 pp. Covers capabilities in aerospace materials (metals, ceramics and plastics) and advanced fabricating methods and equipment for both cryogenic and re-entry service. Includes data checklist for 25 applications. Westinghouse Electric Corp, PO Box 868, Pittsburgh 30.

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**FLOW-METERING ELEMENTS**—Bulletin 100.20-1, 8 pp. Illustrates and outlines line sizes and advantages of 10 differential producers (including Dall flow tubes, venturi tubes and nozzles and plastic Parshall flume liner) for metering water, air or gas, as well as petroleum, alkalies, acids and sewage. B-I-F Industries, PO Box 276, Providence, R.I.

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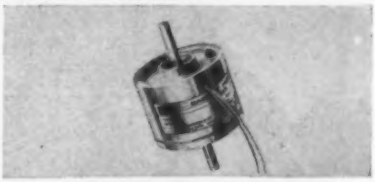

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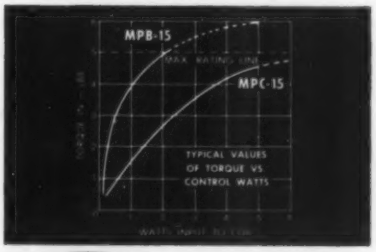


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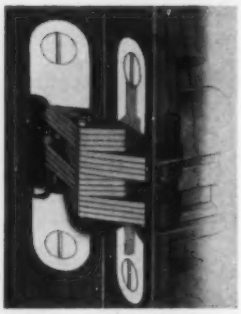

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PIVOTS–Bulletin 700, 4 pp. Covers lengths, diameters, materials and finishes, pivot angles, chamfers and pivot point curvatures of magnetic and non-magnetic pivots. Curves show pivot radius index. Assemblies also are discussed. Welton V Johnson Engineering Co Inc, 95 Summit Ave, Summit, NJ.

**Circle 362 on Reader Service Card**

DC POTENTIOMETERS–Spec bulletin 51-1100BP, 4 pp. Details construction, mounting and performance of null-balance units designed to receive input signal between 200 and 1200 milliv. Fischer & Porter Co, 805 Jacksonville Rd, Warminster, Penna.

**Circle 363 on Reader Service Card**

PRESSURE INDICATOR–Data sheet P-60236, 2 pp. Contains panel-mounting information, adjustment and calibration procedures, specifications and prices. Photo shows unit in typical arrangement with strain gage pressure transducer. Taber Instrument Corp, 107 Goundry St, North Tonawanda, NY.

**Circle 364 on Reader Service Card**

ELECTRICAL CONTACT RIVETS–Bulletin 400, 2 pp. Discusses design features and applications of contact surface, copper-body rivets, and tabulates properties of contact-facing materials. Included are dimensional drawings and illustrations showing varying thicknesses of atomically integrated metal facings. Gibson Electric Sales Corp, Box 400, Delmont, Penna.

**Circle 365 on Reader Service Card**

ENGINE-GENERATOR UNITS–Bulletin, 8 pp. Discusses all components, describes and illustrates control panels and tabulates specifications of diesel and gas models. Waukesha Motor Co, Waukesha, Wis.

**Circle 366 on Reader Service Card**

CONTOURED ENCLOSURES – Data sheets F-10412 and F-10342-1, 2 pp each. Former supplements latter publication's design data on metal enclosures formed in one piece. Includes information on: shapes, materials, strength, electromagnetic shielding, sizes, tolerances and machining characteristics. Barber-Colman Co, Rockford, Ill.

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continued on page 95

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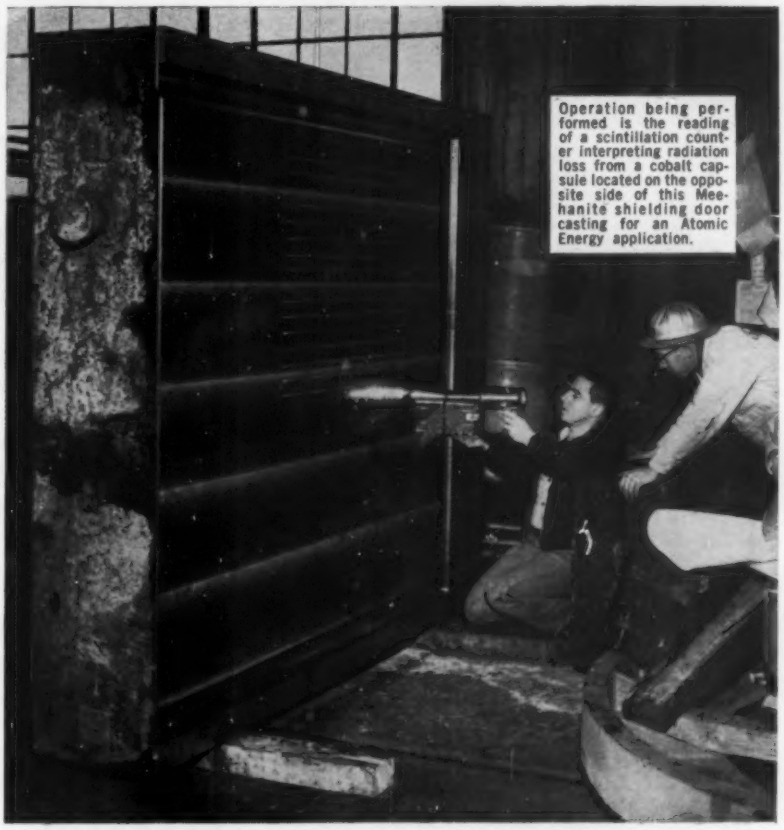
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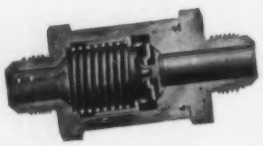

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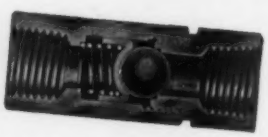

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373—Precision Cold Forgings, 5 pp, Cold Forged Products Co.

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363—DC Potentiometers, 4 pp, Fischer & Porter Co.
365—Electrical Contact Rivets, 2 pp, Gibson Electric Sales Corp.
370—Internal Pinion Counters, 2 pp, Veeder-Root Inc.
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369—Seal-less Centrifugal Pumps, 2 pp, Chempump Div, Fostoria Corp.

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315—Tape Magazine
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304—Rotary Tap Switches
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315—Tape Magazine
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326—Probe-type Level Control
327—Electric Eye Control
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309—Multiple Manifold Sub-base
310—Filter Screen Trap
312—Flow-regulating Valve
314—Air-operated Valves
319—Flowmeter and Filter
320—Low Pressure Sensing Switch
321—Single Pump Power Units
325—Ball Floats Between Valve Seats
326—Probe-type Level Control
328—Hydraulic Pumping Units
329—Single-acting Cylinder
336—Pressure Gages
338—Sight Flow Indicator
339—Pneumatic Line Coupling

*(please print or type)* *If this is change of address, check box* ☐

Name..... Title.....

Street.....

City..... Zone..... State.....

Company..... Major Product Manufactured.....

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21 | 41 | 61 | 81 | 101 | 121 | 141 | 161 | 181 | 201 | 221 | 241 | 261 | 281 | 301 | 316 | 331 | 346 | 361 | 376 |
| 2 | 22 | 42 | 62 | 82 | 102 | 122 | 142 | 162 | 182 | 202 | 222 | 242 | 262 | 282 | 302 | 317 | 332 | 347 | 362 | 377 |
| 3 | 23 | 43 | 63 | 83 | 103 | 123 | 143 | 163 | 183 | 203 | 223 | 243 | 263 | 283 | 303 | 318 | 333 | 348 | 363 | 378 |
| 4 | 24 | 44 | 64 | 84 | 104 | 124 | 144 | 164 | 184 | 204 | 224 | 244 | 264 | 284 | 304 | 319 | 334 | 349 | 364 | 379 |
| 5 | 25 | 45 | 65 | 85 | 105 | 125 | 145 | 165 | 185 | 205 | 225 | 245 | 265 | 285 | 305 | 320 | 335 | 350 | 365 | 380 |
| 6 | 26 | 46 | 66 | 86 | 106 | 126 | 146 | 166 | 186 | 206 | 226 | 246 | 266 | 286 | 306 | 321 | 336 | 351 | 366 | 381 |
| 7 | 27 | 47 | 67 | 87 | 107 | 127 | 147 | 167 | 187 | 207 | 227 | 247 | 267 | 287 | 307 | 322 | 337 | 352 | 367 | 382 |
| 8 | 28 | 48 | 68 | 88 | 108 | 128 | 148 | 168 | 188 | 208 | 228 | 248 | 268 | 288 | 308 | 323 | 338 | 353 | 368 | 383 |
| 9 | 29 | 49 | 69 | 89 | 109 | 129 | 149 | 169 | 189 | 209 | 229 | 249 | 269 | 289 | 309 | 324 | 339 | 354 | 369 | 384 |
| 10 | 30 | 50 | 70 | 90 | 110 | 130 | 150 | 170 | 190 | 210 | 230 | 250 | 270 | 290 | 310 | 325 | 340 | 355 | 370 | 385 |
| 11 | 31 | 51 | 71 | 91 | 111 | 131 | 151 | 171 | 191 | 211 | 231 | 251 | 271 | 291 | 311 | 326 | 341 | 356 | 371 | 386 |
| 12 | 32 | 52 | 72 | 92 | 112 | 132 | 152 | 172 | 192 | 212 | 232 | 252 | 272 | 292 | 312 | 327 | 342 | 357 | 372 | 387 |
| 13 | 33 | 53 | 73 | 93 | 113 | 133 | 153 | 173 | 193 | 213 | 233 | 253 | 273 | 293 | 313 | 328 | 343 | 358 | 373 | 388 |
| 14 | 34 | 54 | 74 | 94 | 114 | 134 | 154 | 174 | 194 | 214 | 234 | 254 | 274 | 294 | 314 | 329 | 344 | 359 | 374 | 389 |
| 15 | 35 | 55 | 75 | 95 | 115 | 135 | 155 | 175 | 195 | 215 | 235 | 255 | 275 | 295 | 315 | 330 | 345 | 360 | 375 | 390 |
| 16 | 36 | 56 | 76 | 96 | 116 | 136 | 156 | 176 | 196 | 216 | 236 | 256 | 276 | 296 | | | | | | |
| 17 | 37 | 57 | 77 | 97 | 117 | 137 | 157 | 177 | 197 | 217 | 237 | 257 | 277 | 297 | | | | | | |
| 18 | 38 | 58 | 78 | 98 | 118 | 138 | 158 | 178 | 198 | 218 | 238 | 258 | 278 | 298 | | | | | | |
| 19 | 39 | 59 | 79 | 99 | 119 | 139 | 159 | 179 | 199 | 219 | 239 | 259 | 279 | 299 | | | | | | |
| 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | | | | | | |

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| P72 | P73 | P75 | P76 | P77 | P78 | P79 | 580 | 581 | 582 | 583 | 584 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 585 | 586 | 587 | 588 | 589 | 590 | 591 | 592 | 593 | 594 | 595 | 596 |

| *MULTIPLE Key No. | PRODUCT ADS Specific Product |
|---|---|
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| | |
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*(please print or type)* *If this is change of address, check box* ☐

Name..... Title.....

Street.....

City..... Zone..... State.....

Company..... Major Product Manufactured.....

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 21 | 41 | 61 | 81 | 101 | 121 | 141 | 161 | 181 | 201 | 221 | 241 | 261 | 281 | 301 | 316 | 331 | 346 | 361 | 376 |
| 2 | 22 | 42 | 62 | 82 | 102 | 122 | 142 | 162 | 182 | 202 | 222 | 242 | 262 | 282 | 302 | 317 | 332 | 347 | 362 | 377 |
| 3 | 23 | 43 | 63 | 83 | 103 | 123 | 143 | 163 | 183 | 203 | 223 | 243 | 263 | 283 | 303 | 318 | 333 | 348 | 363 | 378 |
| 4 | 24 | 44 | 64 | 84 | 104 | 124 | 144 | 164 | 184 | 204 | 224 | 244 | 264 | 284 | 304 | 319 | 334 | 349 | 364 | 379 |
| 5 | 25 | 45 | 65 | 85 | 105 | 125 | 145 | 165 | 185 | 205 | 225 | 245 | 265 | 285 | 305 | 320 | 335 | 350 | 365 | 380 |
| 6 | 26 | 46 | 66 | 86 | 106 | 126 | 146 | 166 | 186 | 206 | 226 | 246 | 266 | 286 | 306 | 321 | 336 | 351 | 366 | 381 |
| 7 | 27 | 47 | 67 | 87 | 107 | 127 | 147 | 167 | 187 | 207 | 227 | 247 | 267 | 287 | 307 | 322 | 337 | 352 | 367 | 382 |
| 8 | 28 | 48 | 68 | 88 | 108 | 128 | 148 | 168 | 188 | 208 | 228 | 248 | 268 | 288 | 308 | 323 | 338 | 353 | 368 | 383 |
| 9 | 29 | 49 | 69 | 89 | 109 | 129 | 149 | 169 | 189 | 209 | 229 | 249 | 269 | 289 | 309 | 324 | 339 | 354 | 369 | 384 |
| 10 | 30 | 50 | 70 | 90 | 110 | 130 | 150 | 170 | 190 | 210 | 230 | 250 | 270 | 290 | 310 | 325 | 340 | 355 | 370 | 385 |
| 11 | 31 | 51 | 71 | 91 | 111 | 131 | 151 | 171 | 191 | 211 | 231 | 251 | 271 | 291 | 311 | 326 | 341 | 356 | 371 | 386 |
| 12 | 32 | 52 | 72 | 92 | 112 | 132 | 152 | 172 | 192 | 212 | 232 | 252 | 272 | 292 | 312 | 327 | 342 | 357 | 372 | 387 |
| 13 | 33 | 53 | 73 | 93 | 113 | 133 | 153 | 173 | 193 | 213 | 233 | 253 | 273 | 293 | 313 | 328 | 343 | 358 | 373 | 388 |
| 14 | 34 | 54 | 74 | 94 | 114 | 134 | 154 | 174 | 194 | 214 | 234 | 254 | 274 | 294 | 314 | 329 | 344 | 359 | 374 | 389 |
| 15 | 35 | 55 | 75 | 95 | 115 | 135 | 155 | 175 | 195 | 215 | 235 | 255 | 275 | 295 | 315 | 330 | 345 | 360 | 375 | 390 |
| 16 | 36 | 56 | 76 | 96 | 116 | 136 | 156 | 176 | 196 | 216 | 236 | 256 | 276 | 296 | | | | | | |
| 17 | 37 | 57 | 77 | 97 | 117 | 137 | 157 | 177 | 197 | 217 | 237 | 257 | 277 | 297 | | | | | | |
| 18 | 38 | 58 | 78 | 98 | 118 | 138 | 158 | 178 | 198 | 218 | 238 | 258 | 278 | 298 | | | | | | |
| 19 | 39 | 59 | 79 | 99 | 119 | 139 | 159 | 179 | 199 | 219 | 239 | 259 | 279 | 299 | | | | | | |
| 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 | 240 | 260 | 280 | 300 | | | | | | |

REPRINTS

| P72 | P73 | P75 | P76 | P77 | P78 | P79 | 580 | 581 | 582 | 583 | 584 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 585 | 586 | 587 | 588 | 589 | 590 | 591 | 592 | 593 | 594 | 595 | 596 |

| *MULTIPLE Key No. | PRODUCT ADS Specific Product |
|---|---|
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| | |
| | |

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Issue of March 27, 1961
PRODUCT ENGINEERING
Card expires May 26, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

**BUSINESS REPLY MAIL**
No Postage Stamp Necessary If Mailed in the United States

Postage Will Be Paid By Reader Service Department

**Inquiries Services Department**
**PRODUCT ENGINEERING**
**P.O. Box 601**
**Ridgefield, Connecticut**

Issue of March 27, 1961
PRODUCT ENGINEERING
Card expires May 26, 1961

FIRST CLASS
PERMIT No. 64
NEW YORK, N. Y.

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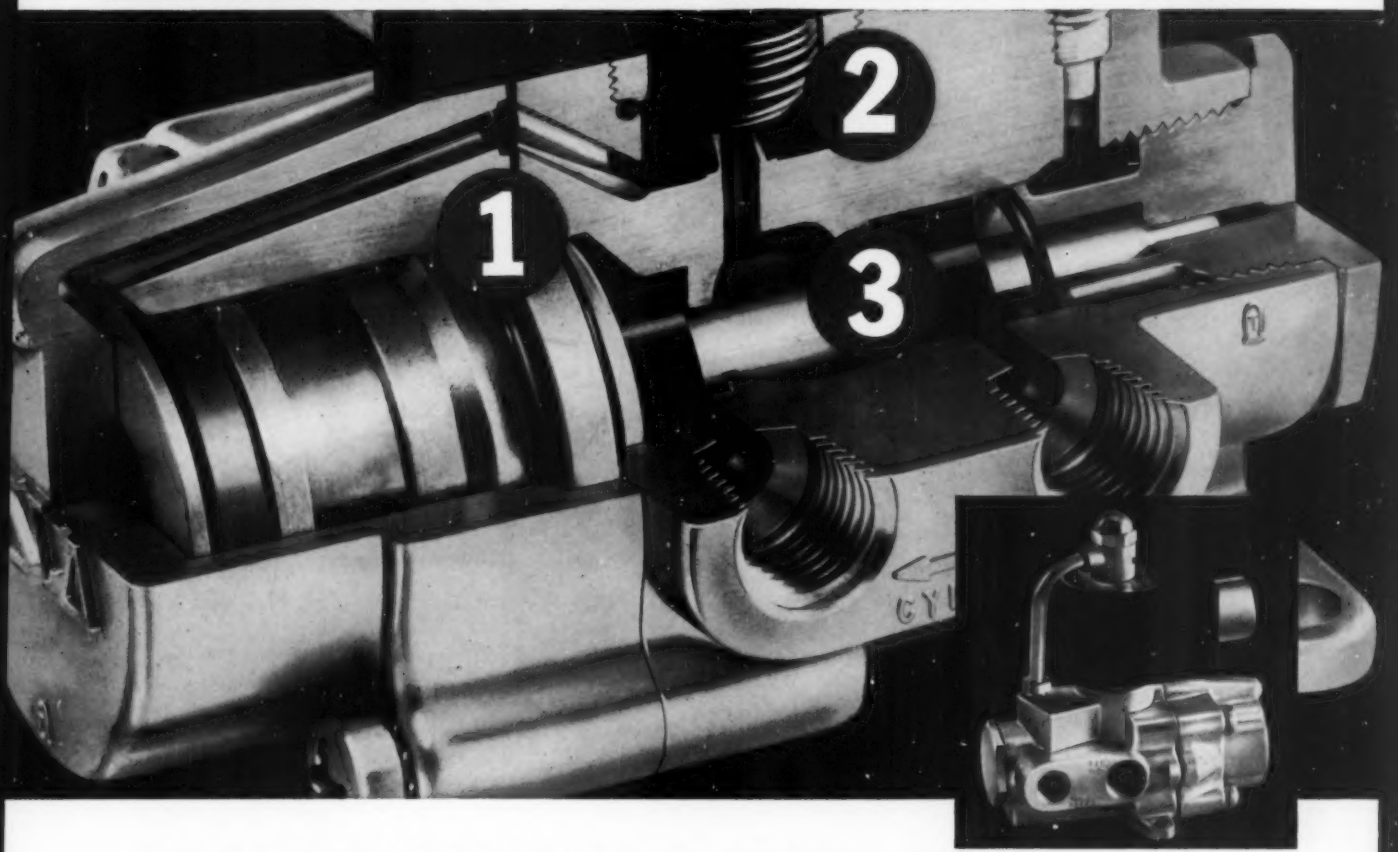
**PRODUCT ENGINEERING**
**P.O. Box 601**
**Ridgefield, Connecticut**

this is the way a valve is built to last

# MILLIONS OF OPERATIONS:




## NEW LOW-COST ASCO 4-WAY SOLENOID VALVES HAVE BEEN CYCLED MILLIONS OF OPERATIONS WITHOUT FAILURE

1. **TIGHT SEATING** with unique patented poppet-type seats—Patent Nos. 2,624,585—2,775,982
2. **RELIABLE OPERATION ASSURED**—failure to return due to residual magnetism is eliminated
3. **POWER OPERATION IN BOTH DIRECTIONS**—main valve not dependent upon return springs

**Installation is simplified; the 8344 may be mounted in any position!**

Poppet seals and a unique combination of metal-to-metal with resilient seating enable these and other ASCO 4-way solenoid valves to provide dead-tight shut-off, even on air, without lapping, grinding or close adjustments. The utter simplicity of design, eliminating return springs and power-operating the main valve in both directions, assures unprecedentedly reliable performance without maintenance for indefinite periods.

The new ASCO Bulletin 8344 valve is the latest embodiment of over half a century's design and development experience. Its low cost makes it economical even as a 3-way valve, with one pipe connection plugged.

Here are the pertinent statistics:

| Pipe Size | Catalog No. | Solenoid Enclosures | List Prices† | Operating Information |
|---|---|---|---|---|
| ¼" | 83440 | Std. | $48.00 | Pressures: to 250 psi. |
| ¼" | 83444 | Expl. proof | 56.00 | Temp: to 212° F. |
| ⅜" | 83441 | Std. | 48.00 | Fluids: air, water, hydraulic oil |
| ⅜" | 83445 | Expl. proof | 56.00 | |

† Subject to trade and quantity discounts.

Other ASCO 4-way valves come in pipe sizes from ¼" to 1½" for pressures to 500 p.s.i. For complete information write for Catalog 202, and see the hundreds of types of 2, 3, and 4-way solenoid valves available for immediate delivery from the world's largest stock.

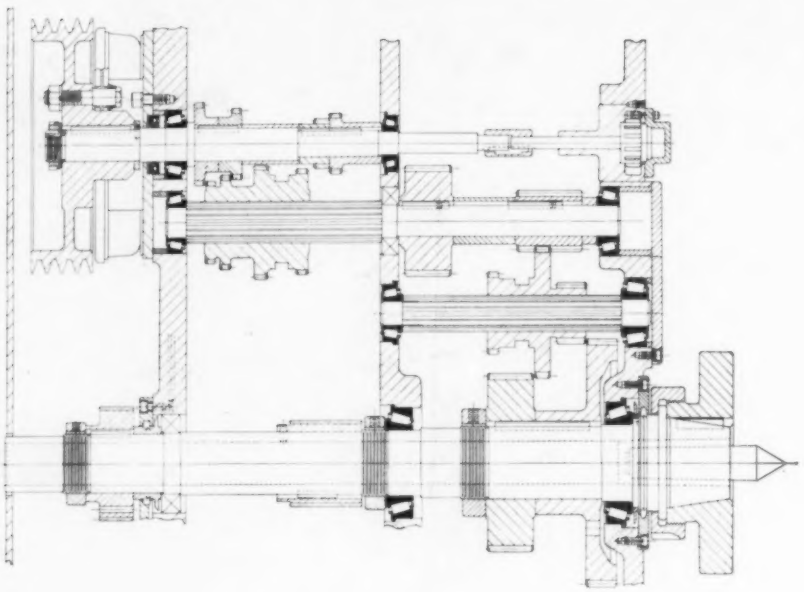
## ASCO Valves

ASCO

DEPENDABLE CONTROL BY Automatic Switch Co. 546 HANOVER RD., FLORHAM PARK, N. J. • FRONTIER 7-4600 • AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

CIRCLE 202 ON READER SERVICE CARD

# LeBLOND lathe obtains super spindle-runout of less than .000025″ with Timken® "00" bearings



To raise the already great precision of its 15″ Dual-Drive lathe to a special new high for a customer, LeBlond had to meet this requirement: spherocity of the part to be turned—a beryllium gyro float assembly—had to be concentric with its two major axes within .0005″ total indicated runout. Diameter of the sphere: 1.8750″.

To assure this, LeBlond engineers specified Timken® super-precision "00" tapered roller bearings held to .000025″ assembled runout for the spindle—one-third the normal runout tolerance for these bearings. Timken bearings were also used on the intermediate, back and feed shafts of the drive. The assembled spindle runout (total indicator reading) was actually less than .000025″.

Producing super-precision bearings like this is typical of Timken Company service. The kind of service that developed Timken "00" bearings to meet industry's needs for ever-greater precision. It's another example of the Timken Company's leadership in tapered roller bearing design and manufacture.

**YOUR BEARING PROBLEMS** can often be solved on-the-spot by our graduate engineer salesmen. Working with you at the design stage, they can help you select the Timken bearing to meet your special needs, save you time and money.

**CIRCLE 203 ON READER SERVICE CARD**

**Industry rolls on**

**TIMKEN®**

**tapered roller bearings**

The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO." *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.* Canadian Division: Canadian Timken, St. Thomas, Ont.